SOIL SURVEY OF

Island of Hawaii, State of Hawaii

United States Department of Agriculture
Soil Conservation Service
In cooperation with
University of Hawaii
Agricultural Experiment Station

Issued December 1973

Major fieldwork for this soil survey was done in the period 1957 to 1967. Soil names and descriptions were approved in 1968. Unless otherwise indicated, statements in this publication refer to conditions in the county in 1968. This survey was made cooperatively by the Soil Conservation Service and the University of Hawaii Agricultural Experiment Station. It is part of the technical assistance furnished to the Soil and Water Conservation Districts on the Island of Hawaii.

Either enlarged or reduced copies of the soil map in this publication can be made by commercial photographers, or they can be purchased on individual order from the Cartographic Division, Soil Conservation Service, United States Department of Agriculture, Washington, D.C. 20250.

HOW TO USE THIS SOIL SURVEY

THIS SOIL SURVEY contains information that can be applied in managing farms and woodlands; in selecting sites for roads, ponds, buildings, and other structures; and in judging the suitability of tracts of land for farming, industry, and community development.

Locating Soils

All the soils of the Island of Hawaii are shown on the detailed map at the back of this publication. This map consists of many sheets made from aerial photographs. Each sheet is numbered to correspond with a number on the Index to Map Sheets.

On each sheet of the detailed map, soil areas are outlined and are identified by symbols. All areas marked with the same symbol are the same kind of soil. The soil symbol is inside the area if there is enough room; otherwise, it is outside and a pointer shows where the symbol belongs.

Finding and Using Information

The "Guide to Mapping Units" can be used to find information. This guide lists all the soils of the island in alphabetic order, by map symbol, according to the kind of survey and gives the capability classification of each. It also shows the page where each soil is described and the page for the woodland, pasture, and sugarcane groups in which the soil has been placed.

Individual colored maps showing the relative suitability or degree of limitation of soils for many specific purposes can be developed by using the soil map and the information in the text. Translucent material can be used as an overlay over the soil map and colored to show soils that have the same limitation or suitability. For example, soils that have a slight limitation for a given use can be colored green, those with a moderate limitation can be colored yellow, and those with a severe limitation can be colored red.

Farmers and those who work with farmers can learn about use and management of the soils from the soil descriptions and from the discussions of the pasture, sugarcane, and woodland groups.

Foresters and others can refer to the section "Woodland," where the soils of the island are grouped according to their suitability for trees.

Game managers, sportsmen, and others can find information about soils and wildlife in the section "Wildlife."

Ranchers and others can find, under "Pasture," groupings of the soils according to their suitability for pasture, and also the names of many of the plants that grow on the soils of each group.

Community planners and others can read about soil properties that affect the choice of sites for nonindustrial buildings and for recreation areas in the sections "Descriptions of the Soils" and "Management of the Soils for Engineering."

Engineers and builders can find, under "Management of the Soils for Engineering," tables that contain test data, estimates of soil properties, and information about soil features that affect engineering practices.

Scientists and others can read about how the soils are classified in the section "Classification of the Soils."

Newcomers to the island may be interested in the "General Soil Map," where broad patterns of soils are described. They may also be interested in the section "General Nature of the Island."

Cover picture: Erupting volcano on the Island of Hawaii.
Photo by Howard Pierce, retired, Hawaii Tribune-Herald

U.S. GOVERNMENT PRINTING OFFICE: 1973

For sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402

Contents

Issued December 1973

SOIL SURVEY OF THE ISLAND OF HAWAII, STATE OF HAWAII

BY HARRY H. SATO, WARREN IKEDA, ROBERT PAETH, RICHARD SMYTHE, AND MINORU TAKEHIRO, JR., SOIL CONSERVATION SERVICE

UNITED STATES DEPARTMENT OF AGRICULTURE, SOIL CONSERVATION SERVICE, IN COOPERATION WITH THE UNIVERSITY OF HAWAII AGRICULTURAL EXPERIMENT STATION

THE ISLAND OF HAWAII is one of the eight major islands of the State of Hawaii (fig. 1). It has an area of 2,579,000 acres or about 4,030 square miles. Although its land area is 62.7 percent of the State, its population of 65,941 is only 8 percent. The island is a county. Hilo, the county seat, is about 216 miles southeast of Honolulu, the State capital.

Farming is the main source of income, and the highly mechanized production of sugarcane has been the main industry. Farming is now diversified, however, and other enterprises, including the production of macadamia nuts, papaya, and truck crops and the culture of orchids, anthuriums, and ornamental foliage are increasing rapidly. The only coffee grown in the United States is pro-

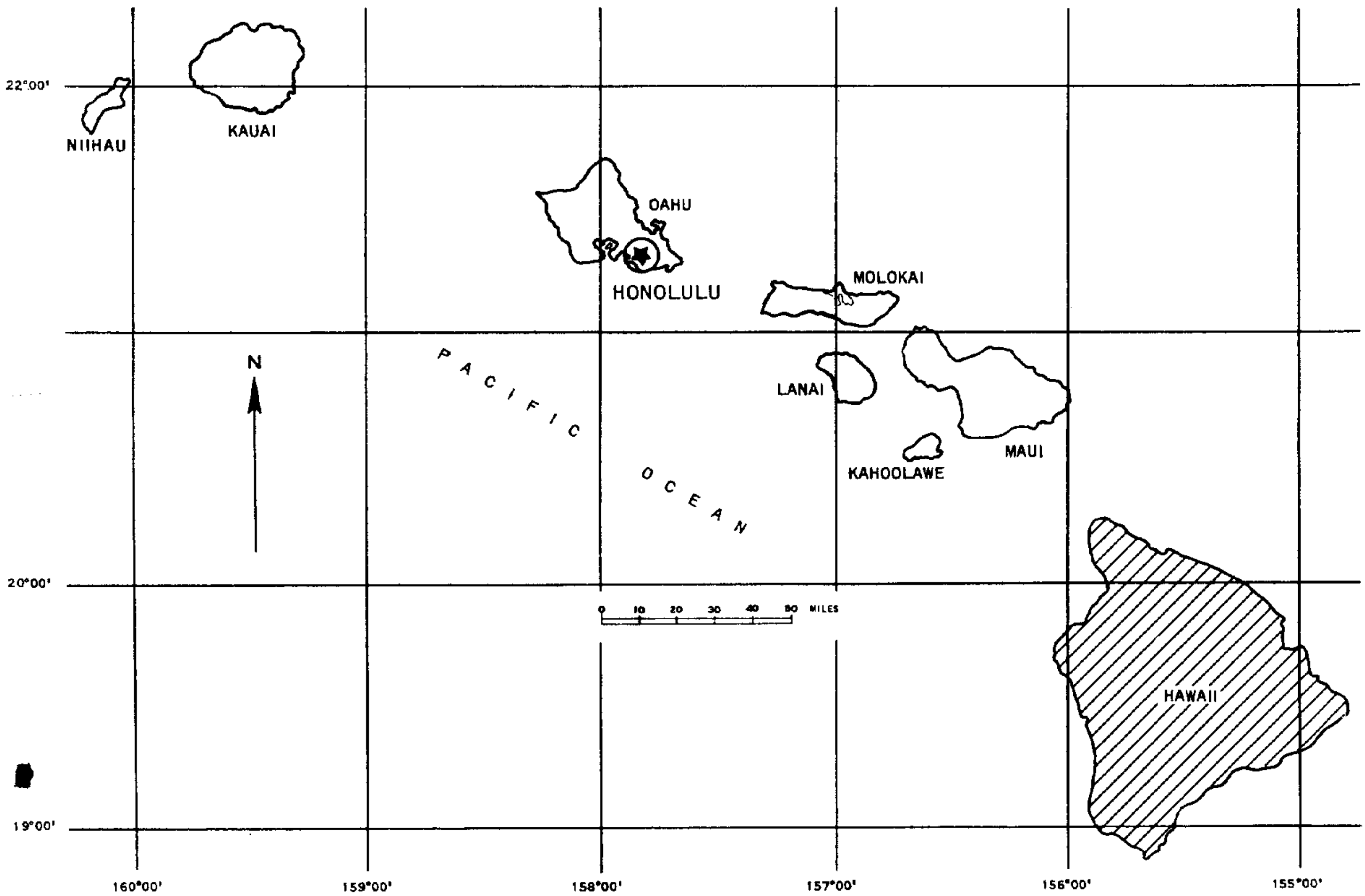


Figure 1.—Location of the Island of Hawaii.

duced in the Kona District. The island leads the State of Hawaii in the production of cattle. Parker Ranch, the second largest in the United States, is in the Kohala District. Tourism also is a growing source of income.

The Island of Hawaii is commonly called the "Volcano Isle," the "Orchid Isle," or the "Big Island" (*13*)[1]. It has the only active volcanoes in the State, one of the most extensive orchid cultures in the world (fig. 2), and the largest land mass in the State. Its lush, green rain forest, its warm, sunny coastal areas, and its snow-covered mountain peaks (fig. 3) provide a variety of scenery and climate.

How This Survey Was Made

Soil scientists made this survey to learn what kinds of soil are on the Island of Hawaii, where they are located, and how they can be used. The soil scientists went on the island knowing they likely would find many soils they had already seen and perhaps some they had not. They observed the steepness, length, and shape of slopes, the size and speed of streams, the kinds of native plants or crops, the kinds of rock, and many facts about the soils. They dug many holes to expose soil profiles. A profile is the sequence of natural layers, or horizons, in a soil; it extends from the surface down into the parent material that has not been changed much by leaching or by the action of plant roots.

The soil scientists made comparisons among the profiles they studied, and they compared these profiles with those on islands nearby and in places more distant. They classified and named the soils according to nationwide, uniform procedures.

Soils that have profiles almost alike make up a soil series. Except for different texture in the surface layer, all the soils of one series have major horizons that are similar in thickness, arrangement, and other important characteristics. Each soil series is named for a town or other geographic feature near the place where a soil of that series was first observed and mapped. Hilo and Honokaa, for example, are the names of two soil series. All the soils in the United States having the same series name are essentially alike in those characteristics that affect their behavior in the undisturbed landscape.

Soils of one series can differ in the texture of their surface layer, and according to such a difference, they

[1] Italic numbers in parentheses refer to Literature Cited, page 112.

Figure 2.—Joaquin vanda orchids planted on tree fern stump on Cinder land in Kapoho.

Figure 3.—**Snow-covered peak of Mauna Kea, seen from Hilo Bay.**

are divided into types. Hilo silty clay loam, for example, is a soil type in the Hilo series. Most of the series in this survey have only one soil type. Some soil types vary so much in slope, degree of erosion, stoniness, or some other feature affecting their use that practical suggestions about their management could not be made if they were shown on the soil map as one unit. Such soil types are divided into phases. The name of a soil phase indicates a feature that affects management. Hilo silty clay loam, 0 to 10 percent slopes, is a phase of Hilo silty clay loam.

After a guide for classifying and naming the soils had been worked out, the soil scientists drew the boundaries of the individual soils on aerial photographs. These photographs show woodlands, buildings, field borders, trees, and other details that help in drawing boundaries accurately. The soil map at the back of this publication was prepared from aerial photographs.

The areas shown on a soil map are called mapping units. On most maps detailed enough to be useful in planning the management of farms and fields, a mapping unit is nearly equivalent to a soil phase. It is not exactly equivalent, because it is not practical to show on such a map all the small, scattered bits of soil of some other kind that have been seen within an area that is dominantly of a recognized soil phase.

Some mapping units are made up of soils of different series. One such mapping unit is the soil association. A soil association is made up of adjacent soils that occur as areas large enough to be shown individually on the soil map but are shown as one unit because the time and effort of delineating them separately cannot be justified. There is a considerable degree of uniformity in pattern and relative extent of the dominant soils, but the soils may differ greatly one from another. The name of an association consists of the names of the

dominant soils, joined by a hyphen. Amalu-Rough broken land association is an example.

In most areas surveyed there are places where the soil material is so rocky, so shallow, or so severely eroded that it cannot be classified by soil series. These places are shown on the soil map and are described in the survey, but they are called land types and are given descriptive names, such as Fill land.

While a soil survey is in progress, samples of soils are taken, as needed, for laboratory measurements and for engineering tests. Laboratory data from the same kinds of soil in other places are assembled. Data on yields of crops under defined practices are assembled from farm records and from field or plot experiments on the same kinds of soil. Yields under defined management are estimated for all the soils.

But only part of a soil survey is done when the soils have been named, described, and delineated on the map, and the laboratory data and yield data have been assembled. The mass of detailed information then needs to be organized in such a way as to be readily useful to different groups of users, among them engineers, farmers, and managers of woodland, pasture, and wildlife.

On the basis of yield and practice tables and other data, the soil scientists set up trial groups. They test these groups by further study and by consultation with farmers, agronomists, engineers, and others, then adjust the groups according to the results of their studies and consultation. Thus, the groups that are finally evolved reflect up-to-date knowledge of the soils and their behavior under present methods of use and management.

General Soil Map

The general soil map at the back of this survey shows, in color, the soil associations on the Island of Hawaii. A soil association is a landscape that has a distinctive proportional pattern of soils. It normally consists of one or more major soils and at least one minor soil, and it is named for the major soils. The soils in one association may occur in another, but in a different pattern.

A map showing soil associations is useful to people who want a general idea of the soils on the island, who want to compare different parts of the island, or who want to know the location of large tracts that are suitable for a certain kind of land use. Such a map is a useful general guide in managing a watershed, a wooded tract, or a wildlife area, or in planning engineering works, recreational facilities, and community developments. It is not a suitable map for planning the management of a farm or field, or for selecting the exact location of a road, building, or similar structure, because the soils in any one association ordinarily differ in slope, depth, stoniness, drainage, and other characteristics that affect their management.

The soil associations on the Island of Hawaii are discussed in the following pages.

1. Lava flows association

Gently sloping to steep, excessively drained, nearly barren lava flows; on uplands

This association consists of excessively drained, nearly barren lava flows and somewhat excessively drained and well-drained, coarse-textured and medium-textured soils that formed in volcanic ash, pumice, and cinders. These soils are on mountains at an elevation ranging from near sea level to 13,000 feet. They receive an annual rainfall of 10 to 250 inches. The mean annual soil temperature is between 49° and 76° F. The natural vegetation consists of lichen, moss, ohia, amaumau fern, mamane, naio, Kentucky bluegrass, and sweet vernal.

This soil association makes up about 50 percent of the island area, and most of it is in the saddle between Mauna Loa and Mauna Kea, near the summit of Mauna Kea, and near Pahala. Pahoehoe lava flows make up about 40 percent of this association, and Aa lava flows about 30 percent. The main soil series are Apakuie, Huikau, and Kilohana, each of which makes up about 3 percent of the association. The remaining 21 percent consists of Kilauea, Heake, and Keekee soils, and of Rock land, Rough broken land, Very stony land, Beaches, Cinder land, and Fill land.

Pahoehoe lava flows have a smooth, ropy surface. Aa lava flows are a mass of clinkery, hard, sharp lava fragments. Apakuie, Huikau, and Kilohana soils are near the summit of Mauna Kea. Apakuie soils have a dark reddish-brown and dusky-red very fine sandy loam surface layer underlain by dark reddish-brown very fine sandy loam and loamy sand. Huikau soils have a very dark brown loamy sand surface layer underlain by dark reddish-brown sandy loam and loamy sand and by slightly weathered volcanic ash, cinders, and pumice. Kilohana soils have a very dark brown loamy fine sand surface layer over dark-brown and very dark gray fine sand.

Beaches consist of coral sand, black sand, or olivine sand. Cinder land is a mixture of fine cinders, pumice, and volcanic ash. Rock land consists of very shallow soils where rock outcrop occupies 50 to 90 percent of the surface. Rough broken land is made up of very steep and precipitous areas broken by many intermittent drainage channels. Very stony land consists of very shallow soils that have stones covering 30 to 70 percent of the surface.

This soil association is used for grazing, wildlife habitat, and recreation. The carrying capacity for grazing and wildlife is low. The wildlife consists of goats, sheep, pigs, pheasants, and quails. Sheep are common near the summit of Mauna Kea. Goats are in the stony areas.

2. Kekake-Keei-Kiloa association

Very shallow, gently sloping to steep, well-drained organic soils over Aa or pahoehoe lava; on uplands

This soil association consists of well-drained, very shallow soils that formed in organic matter over pahoehoe lava or fragmental Aa lava (fig. 4). These soils are on mountains at an elevation ranging from near sea level to

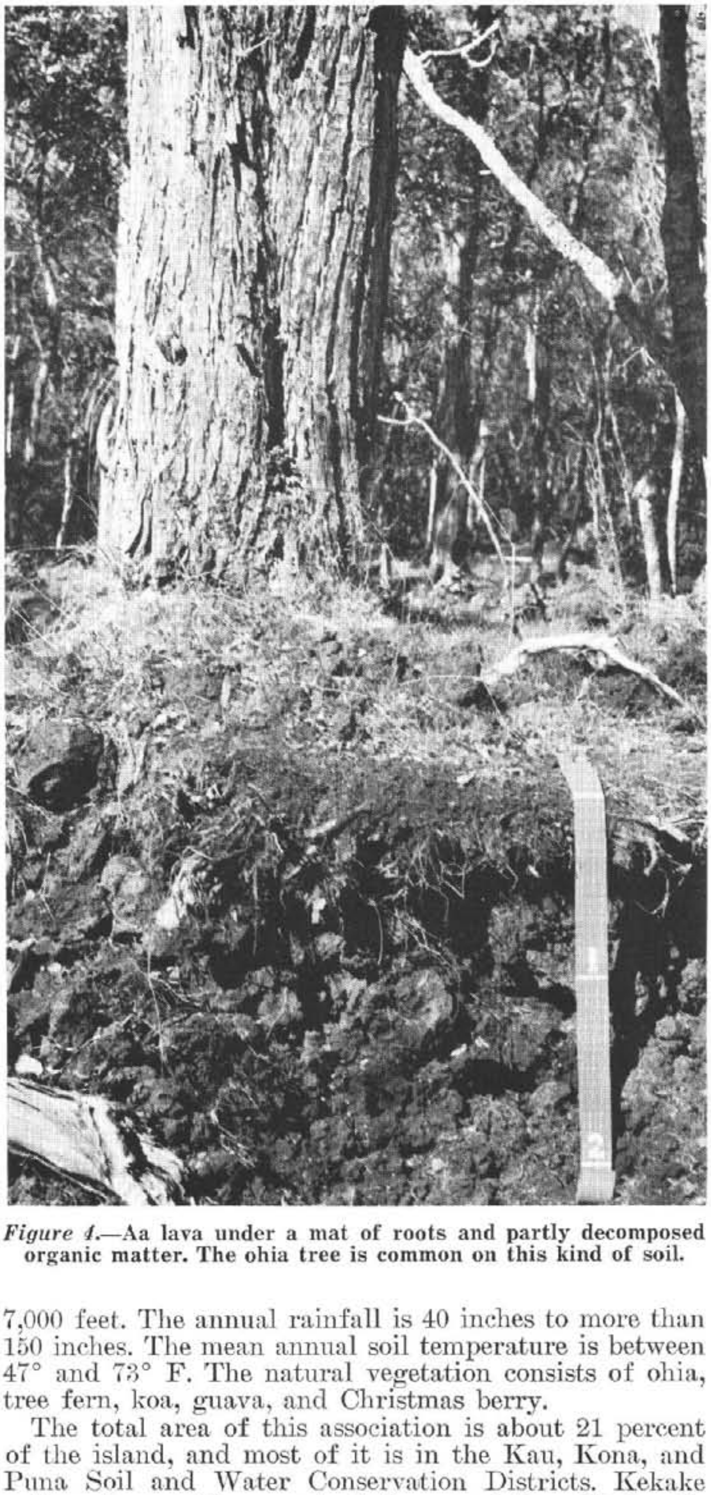


Figure 4.—**Aa lava under a mat of roots and partly decomposed organic matter. The ohia tree is common on this kind of soil.**

7,000 feet. The annual rainfall is 40 inches to more than 150 inches. The mean annual soil temperature is between 47° and 73° F. The natural vegetation consists of ohia, tree fern, koa, guava, and Christmas berry.

The total area of this association is about 21 percent of the island, and most of it is in the Kau, Kona, and Puna Soil and Water Conservation Districts. Kekake soils make up 20 percent of the association, Keei soils 15 percent, Kiloa soils 12 percent, and Kahaluu soils 10 percent. The remaining 43 percent consists of Kaimu, Keaukaha, Kealakekua, Kona, Lalaau, Malama, Mawae, Opihikao, Papai, Puna, and Punaluu soils.

Kekake, Keei, Kahaluu, Keaukaha, Kona, Opihikao, and Punaluu soils are 2 to 12 inches deep over pahoehoe lava bedrock. Kekake soils have a black, mucky surface layer and a mean annual soil temperature of about 51° F. Keei soils have a very dark brown, mucky surface layer and a mean annual soil temperature of about 63° F.

Kaimu, Kiloa, Lalaau, Malama, Mawae, Papai, and Puna soils are 2 to 12 inches deep over fragmental Aa lava. Kiloa soils have an extremely stony, mucky surface layer and a mean annual soil temperature of about 65° F.

This association is used for pasture, woodland, watershed, and recreation. In addition, Kiloa, Malama, Papai, and Puna soils are used for macadamia nuts, and some areas of Kaimu and Punaluu soils are used for papaya. The wildlife consists mainly of wild pigs.

3. *Hanipoe-Maile-Puu Oo association*

Deep, gently sloping to steep, well-drained soils that have a medium-textured to moderately fine textured subsoil; on uplands

In this soil association are medium-textured to moderately fine textured soils that formed in volcanic ash. These soils have a dark surface layer that is high in content of organic matter. They are on mountains at an elevation ranging from 2,500 to 8,000 feet and receive from 30 to 120 inches of rainfall annually. The mean annual soil temperature is between 54° and 62° F. The natural vegetation consists of ohia, koa, naio, mamane, tree fern, rattail, brome, kikuyugrass, and orchardgrass.

The total area of this association is about 6 percent of the island. Hanipoe soils make up 30 percent of the association, Maile soils 20 percent, and Puu Oo soils 10 percent. The remaining 40 percent consists of Kapapala, Laumaia, Manu, Manahaa, Palapalai, Puhimau, Punohu, and Umikoa soils.

Hanipoe soils are in the Mauna Kea, Kona, and Kau Soil and Water Conservation Districts. These soils have a surface layer of dark reddish-brown to very dark brown silt loam and a subsoil of dark-brown, dark reddish-brown, and very dark brown silt loam. Maile soils are in the Mauna Kea Soil and Water Conservation District. Their surface layer is dark reddish-brown to very dark brown silt loam, and their subsoil is dark-brown to dark yellowish-brown silty clay loam. Puu Oo soils are on the eastern slopes of Mauna Kea. They have a surface layer of dark reddish-brown and very dark gray silt loam and a subsoil of very dark brown to dark reddish-brown silty clay loam.

This association is used for pasture and woodland. It produces some of the finest pasture on the island and has some excellent stands of tree plantings. The soils are favorable for many kinds of vegetables, but most areas are too steep for intensive cultivation and erosion control. The wildlife consists of wild pigs, pheasants, doves, and quails.

4. *Amalu-Kahua-Kehena association*

Shallow to deep, gently sloping to steep, poorly drained to somewhat poorly drained soils that have a moderately fine textured subsoil; on uplands

This soil association consists of moderately fine textured soils that formed in volcanic ash. These soils are

on the Kohala Mountains at an elevation ranging from near sea level to 5,500 feet. They receive 80 inches to more than 200 inches of rainfall annually. The mean annual soil temperature is between 56° and 75° F. The natural vegetation consists of kikuyugrass, hilograss, sedges, ohia, and guava.

The total area of this association is about 2 percent of the island. Amalu soils make up 62 percent of the association, Kahua soils 24 percent, and Kehena soils about 8 percent. Mixed alluvial land and Tropaquepts make up the rest.

Amalu soils have a layer of partly decomposed moss and other organic matter over a surface layer of dark-gray mucky silt loam. Their subsoil is dark-brown to very dark grayish-brown silty clay loam. An ironstone seam occurs in them at a depth of 15 to 20 inches. Kahua soils have a very dark brown silt loam surface layer and a subsoil of dark-brown to very dark grayish-brown silty clay loam. A thin ironstone seam occurs in these soils at a depth of 8 to 40 inches. Kehena soils have a surface layer of dark-brown silty clay loam and a subsoil of dark-brown to very dark grayish-brown silty clay loam. Mixed alluvial land consists of very stony soil material derived from alluvium that washed from wet soils. Tropaquepts consist of very poorly drained soil material that varies in texture and is shallow over poorly sorted sandy and gravelly alluvium.

Kahua and Kehena soils are used for pasture, woodland, watershed, and wildlife. Amalu soils are used for watershed and wildlife. Tropaquepts are used for growing taro. Forage in this soil association has low nutritional value and very low content of dry matter. The wildlife consists mainly of wild pigs.

5. *Kawaihae association*

Moderately deep, gently sloping to moderately steep, somewhat excessively drained soils that have a medium-textured subsoil; on coastal plains

In this association are medium-textured soils that formed in volcanic ash. These soils are on coastal plains at an elevation ranging from near sea level to 1,500 feet. They receive 5 to 20 inches of rainfall annually, and their mean annual soil temperature is between 74° and 77° F. The natural vegetation consists of kiawe, ilima, piligrass, uhaloa, and buffelgrass.

The area of this association is about 1 percent of the island. Kawaihae soils make up most of the association. Included with them are Kamaoa soils, Very stony land, and Rock land. Also included are small areas of the alluvial Kamakoa soils in drainage ditches.

Kawaihae soils have a surface layer of dark reddish-brown, extremely stony very fine sandy loam. Their subsoil is dark reddish-brown and dusky-red silt loam. Bedrock is at a depth of 20 to 40 inches. Calcium carbonate is encrusted on rocks or is concentrated in a layer in the lower part of the profile.

This association is used for pasture. The ranches are large, but the carrying capacity is low and the water supply is limited. The wildlife consists of pheasants, quails, doves, and goats.

6. *Akaka-Honokaa-Kaiwiki association*

Deep, gently sloping to steep, moderately well drained and well drained soils that have a moderately fine textured subsoil; on uplands

This soil association consists of moderately fine textured soils that formed in volcanic ash. These soils are high in organic-matter content, are very porous, and are continuously wet. They are on mountains at an elevation ranging from near sea level to 6,000 feet. They receive from 80 inches to more than 200 inches of rainfall annually, and their mean annual soil temperature is between 54° and 75° F. Their natural vegetation is ohia, tree fern, koa, and false staghorn fern.

The total area of this association is about 11 percent of the island. Akaka soils make up about 40 percent of the association, the Hydrandept-Tropofolist association 15 percent, Honokaa soils 10 percent, and Kaiwiki soils 10 percent. The remaining 25 percent consists of Alapai, Hilea, Hilo, Honaunau, Kealakekua, Ohia, Olaa, Panaewa, Piihonua, and Puaulu soils.

Akaka soils are in the eastern part of the island between Glenwood and Laupahoehoe. They have a dark reddish-brown silty clay loam surface layer. Their subsoil is reddish-brown to dark reddish-brown silty clay loam. Hydrandept-Tropofolist soils are in the Kau Soil and Water Conservation District. These are deep soils in volcanic ash and shallow, wet, organic soils over fragmental Aa and pahoehoe lava flows. Honokaa soils are in the Honokaa area. They have a dark-brown silty clay loam surface layer and a silty clay loam subsoil that is dark brown, very dark brown, and very dark grayish brown. Kaiwiki soils are between Hilo and Laupahoehoe. They have a dark-brown surface layer and a dark-brown and dark reddish-brown silty clay loam subsoil.

The major soils and some of the minor soils of this association are used for sugarcane. The Akaka soils and some of the minor soils are used for woodland, and the Honokaa and Kealakekua soils are used for pasture, truck crops, macadamia nuts, and coffee. Forage in this association has low nutritional value and very low content of dry matter. The potential for timber is high. The wildlife consists of wild pigs.

7. *Waimea-Kikoni-Naalehu association*

Very deep, nearly level to steep, well-drained soils that have a medium-textured to moderately fine textured subsoil; on uplands

This association consists of medium-textured to moderately fine textured soils that formed in volcanic ash. These soils have a dark surface layer that is high in content of organic matter. They are on mountains at an elevation ranging from 750 to 6,000 feet. They receive from 25 to 70 inches of rainfall annually, and their mean annual soil temperature is between 66° and 72° F. The natural vegetation consists of bermudagrass, lantana, guava, rattail, kikuyugrass, and whiteclover.

The area of this soil association is about 2 percent of the island. Waimea soils make up 65 percent of the

association, Kikoni soils 20 percent, and Naalehu soils 15 percent.

Waimea and Kikoni soils are in the Mauna Kea Soil and Water Conservation District. Waimea soils have a surface layer of very dark brown and dark-brown very fine sandy loam and loam. Their subsoil is dark-brown silt loam. Kikoni soils have a surface layer of very dark brown very fine sandy loam. Their subsoil is dark-brown and dark reddish-brown very fine sandy loam and silt loam. Naalehu soils are in the Kau Soil and Water Conservation District. These soils have a very dark brown silty clay loam surface layer. The upper part of their subsoil is dark-brown silty clay loam, and the lower part is dark reddish-brown silt loam.

Waimea and Kikoni soils are used for pasture and, in small areas, for truck crops. Naalehu soils are used for sugarcane. The pastures of the Waimea and Kikoni soils provide habitat for pheasants, quails, and doves.

8. Puu Pa-Pakini-Waiaha association

Shallow to deep, nearly level to steep, well-drained to somewhat excessively drained soils that have a medium-textured subsoil or medium-textured underlying material; on uplands

This soil association consists of moderately coarse textured to moderately fine textured soils that formed in volcanic ash. Most of these soils have a concentration of calcium carbonate that occurs as a soil layer or as coatings on rock fragments. These soils are on mountains and alluvial plains at an elevation ranging from near sea level to 4,000 feet. They receive 20 to 60 inches of rainfall annually and have a mean annual soil temperature that is between 63° and 76° F. The natural vegetation is lantana, natal redtop, Japanese tea, cactus, and kiawe.

The area of this soil association is about 3 percent of the island. Puu Pa soils make up about 60 percent of the association, Pakini soils 10 percent, and Waiaha soils about 10 percent. The remaining 20 percent is made up of Kaalualu, Kainaliu, Kamakoa, Kamaoa, and Waikaloa soils.

Puu Pa soils are in the northwestern part of the island. These soils have a very dark brown extremely stony very fine sandy loam surface layer. Their subsoil is dark-brown and dark yellowish-brown very stony very fine sandy loam. Pakini soils are in the southernmost part of the island. They have a very dark brown and dark-brown very fine sandy loam surface layer. Their subsoil is brown loam that contains an accumulation of calcium carbonate at a depth of 30 to 55 inches. Waiaha soils are mostly in the Kona Soil and Water Conservation District, except for small areas in the Kau district. They have a very dark brown extremely stony silt loam surface layer and a dark-brown very stony silt loam subsoil. These soils are less than 20 inches deep over bedrock.

This association is used mainly for pasture, and the pasture is excellent. Kainaliu soils are used for truck crops, coffee, macadamia nuts, and pasture. The wildlife consists of pheasants, quails, and doves.

9. Kukaiau-Ainakea-Paauhau association

Deep and moderately deep, gently sloping to steep, well-drained soils that have a moderately fine textured subsoil; on uplands

This soil association consists of moderately fine textured soils that formed in volcanic ash and basic igneous rock. These soils are on mountains at an elevation ranging from near sea level to 2,500 feet. They receive from 50 to 140 inches of rainfall annually, and their mean annual soil temperature is between 66° and 71° F. The natural vegetation consists of bermudagrass, hilograss, molassesgrass, kikuyugrass, guava, and Christmas berry.

The area of this association is about 3 percent of the island. Kukaiau soils make up 25 percent of the association, Ainakea soils 20 percent, and Paauhau soils 18 percent. The remaining 37 percent consists of Honuaulu, Moaula, Niulii, Ookala, and Puukala soils.

Kukaiau and Paauhau soils are between Kukaiau and Kukuihaele. These soils have a very dark grayish-brown silty clay loam surface layer and a dark-brown silty clay loam subsoil. Ainakea soils are in the Mauna Kea Soil and Water Conservation District. They have a dark-brown silty clay loam surface layer and a dark-brown silty clay loam subsoil.

All of these soils, except Honuaulu and Puukala soils, are used for nonirrigated sugarcane. Small areas are used for truck crops, orchards, and pasture. Coffee is grown on the Honuaulu soils. Puukala soils are used for pasture and woodland. The wildlife consists of pheasants and wild pigs.

10. Kohala-Hawi-Mahukona association

Deep, gently sloping to steep, well-drained soils that have a moderately fine textured to fine textured subsoil; on uplands

In this soil association are fine-textured soils that formed in basic igneous rock and volcanic ash. These soils have a concentration of manganese dioxide in the upper part of the profile. They are on the Kohala Mountains at an elevation ranging from near sea level to 1,500 feet. They receive from 20 to 60 inches of rainfall annually, and their mean annual soil temperature is between 72° and 74° F. The natural vegetation consists of guava, lantana, bermudagrass, natal redtop, ilima, and kiawe.

The area of this association is about 1 percent of the island. Kohala soils make up about 45 percent of the association, Hawi soils 40 percent, and Mahukona soils 15 percent.

Kohala soils have a surface layer of very dark grayish-brown and dark-brown silty clay and a subsoil of dark-brown to dark yellowish-brown silty clay. Hawi soils have a very dark grayish-brown silty clay surface layer and a dark-brown to dark yellowish-brown stony silty clay subsoil. Mahukona soils have a dark reddish-brown very stony silty clay loam surface layer and a dark reddish-brown and dusky-red silty clay loam subsoil.

This association is used for irrigated sugarcane and for pasture. Small areas are used for irrigated truck crops and macadamia nuts. The wildlife consists mostly of pheasants, chukar partridges, and doves.

424-785—73——2

Descriptions of the Soils

This section describes in alphabetical order the soil series and mapping units of the Island of Hawaii. A general description of each series is followed by a technical description of the mapping unit that is representative of the series. This is followed by brief descriptions of the remaining mapping units of the series.

Three kinds of survey were made on the island. A high-intensity survey was made on all cultivated areas; a low-intensity survey was made of all grazing and forested land; and a reconnaissance survey was made on inaccessible areas. The composition of the low-intensity mapping units is more variable than that of the high-intensity units but the survey has been controlled well enough to allow interpretations for the expected uses of the soils.

Following the name of each soil, or mapping unit, is a symbol in parentheses. This symbol identifies the soil on the soil map and indicates the intensity of the survey. For a soil within the high-intensity survey, the symbol consists of a combination of capital and lowercase letters (AaC). It includes a number if the soil is eroded. For a soil within the low-intensity survey, the symbol consists of capital letters (AFD). For a soil within the reconnaissance survey, the symbol consists of a lowercase "r" preceding the capital letters (rAK).

In describing a soil profile, the scientist assigns a symbol, for example "A1," to the various layers. These symbols have a special meaning for soil scientists and others who make detailed studies of the soils. Most readers will need to remember only that all symbols beginning with "A" are for the surface layer; those beginning with "B" are for the subsoil; those beginning with "C" are for the substratum, or parent material; and those beginning with "R" are for bedrock. All measurements refer to depth from the surface.

The color of each horizon is described in words, such as "yellowish brown," and is also indicated by symbols for hue, value, and chroma, such as 10YR 5/4. These symbols, called Munsell color notations, are used by soil scientists to evaluate the color of the soil precisely.

The texture of the soil refers to the content of sand, silt, and clay. It is determined by the way the soil feels when rubbed between the fingers, and it is checked by laboratory analyses. Each mapping unit is identified by a textural class name, such as "fine sandy loam." This name refers to the texture of the surface layer, or A horizon.

The structure is indicated by the way the individual soil particles are arranged in larger grains, or aggregates, and the amount of pore space between grains. The structure of the soil is described by terms that denote strength or grade, size, and shape of the aggregates. For example, a layer may consist of soil that has "weak, fine, blocky structure."

Boundaries between the horizons are described to indicate their thickness and shape. The terms for thickness are *abrupt*, *clear*, *gradual*, and *diffuse*. The shape of the boundary is described as *smooth*, *wavy*, *irregular*, or *broken*.

Listed in parentheses at the end of the description of each mapping unit are the capability class or subclass and the sugarcane, pasture, or woodland group in which the soil has been placed. These groups are discussed in the section "Use and Management of the Soils."

Technical terms used for describing the soils are defined in the Soil Survey Manual (*19*) and in the Glossary at the back of this publication. For more general information about the soils, the reader can refer to the section "General Soil Map," in which the broad patterns of soils are described. The approximate acreage and proportionate extent of the soils are given in table 1.

Ainakea Series

The Ainakea series consists of well-drained silty clay loams that formed in volcanic ash and are underlain by basic igneous rock. These soils are gently sloping to steep. They are on uplands at an elevation ranging from near sea level to 1,800 feet. The annual rainfall is 60 to 90 inches and is well distributed throughout the year. The mean annual soil temperature is between 68° and 71° F. The natural vegetation consists of guava, hilograss, and Christmas berry. These soils are in the same general area as Kohala and Niulii soils.

Ainakea soils are used for sugarcane and macadamia nuts and as homesites.

Ainakea silty clay loam, 3 to 12 percent slopes (AaC).—This soil is on the lower slopes of the Kohala Mountains where it is dissected by deep, narrow gulches.

In a representative profile the surface layer is dark-brown silty clay loam about 10 inches thick. The subsoil is dark-brown silty clay loam about 20 inches thick. The substratum is soft, weathered basic igneous rock. The surface layer is extremely acid, and the subsoil is medium acid to strongly acid.

Representative profile, Hawi Quadrangle, lat. 20°12′55″ N. and long. 155°47′58″ W.:

Ap—0 to 10 inches, dark-brown (10YR 3/3) silty clay loam; dark yellowish brown (10YR 4/4) when dry; strong, fine and medium, granular structure; hard, friable, slightly sticky, and plastic; many roots; many very fine and fine pores; common hard lava fragments from pebble to stone size; weak effervescence with hydrogen peroxide; extremely acid; abrupt, wavy boundary. (8 to 12 inches thick)

B1—10 to 18 inches, dark-brown (7.5YR 3/4) silty clay loam; dark yellowish brown (10YR 3/4) when dry; moderate, fine and very fine, subangular blocky structure; very hard, friable, sticky, plastic, and nonsmeary; common roots; many very fine and fine pores; common lava fragments from pebble to stone size; no effervescence with hydrogen peroxide; strongly acid; abrupt, wavy boundary. (6 to 9 inches thick)

B2—18 to 30 inches, dark-brown (10YR 3/3) silty clay loam; dark yellowish brown (10YR 4/4) when dry; strong, very fine and fine, subangular blocky structure; very hard, friable, sticky, plastic, and nonsmeary; common roots; many very fine and fine pores; common lava fragments from pebble to stone size; no effervescence with hydrogen peroxide; medium acid; abrupt, wavy boundary. (10 to 15 inches thick)

IIR—30 inches, slightly weathered basalt bedrock.

The hue of the solum ranges from 7.5YR to 10YR. The effervescence with hydrogen peroxide ranges from moderate

TABLE 1.—*Approximate acreage and proportionate extent of the soils*

Soil	Area	Extent
HIGH-INTENSITY SURVEY		
	Acres	*Percent*
Ainakea silty clay loam, 3 to 12 percent slopes	3,985	0.15
Ainakea silty clay loam, 12 to 20 percent slopes	3,183	.12
Ainakea silty clay loam, 20 to 35 percent slopes	861	.03
Akaka silty clay loam, 0 to 10 percent slopes	19,468	.76
Akaka silty clay loam, 10 to 20 percent slopes	5,181	.20
Alapai silty clay loam, 0 to 10 percent slopes	2,151	.08
Alapai silty clay loam, 10 to 20 percent slopes	1,558	.06
Alapai silty clay loam, 20 to 35 percent slopes	492	.02
Alapai extremely stony silty clay loam, 10 to 20 percent slopes	2,950	.11
Hawi silty clay, 0 to 3 percent slopes	1,563	.06
Hawi silty clay, 3 to 12 percent slopes	1,210	.05
Hawi extremely stony silty clay, 6 to 12 percent slopes	6,006	.23
Hilea silty clay loam, 6 to 12 percent slopes	7,499	.29
Hilo silty clay loam, 0 to 10 percent slopes	9,039	.35
Hilo silty clay loam, 10 to 20 percent slopes	3,687	.14
Hilo silty clay loam, 20 to 35 percent slopes	1,484	.06
Honokaa silty clay loam, low elevation, 0 to 10 percent slopes	2,036	.08
Honokaa silty clay loam, low elevation, 10 to 20 percent slopes	7,754	.30
Honokaa silty clay loam, low elevation, 20 to 35 percent slopes	2,019	.08
Kaiwiki silty clay loam, 0 to 10 percent slopes	5,811	.23
Kaiwiki silty clay loam, 10 to 20 percent slopes	11,349	.44
Kaiwiki silty clay loam, 20 to 35 percent slopes	2,845	.11
Kikoni very fine sandy loam, 0 to 3 percent slopes	1,317	.05
Kohala silty clay, 0 to 3 percent slopes	2,721	.11
Kohala silty clay, 3 to 12 percent slopes	6,013	.23
Kohala silty clay, 12 to 20 percent slopes	971	.04
Kohala silty clay, 20 to 35 percent slopes	304	.01
Kukaiau silty clay loam, 6 to 12 percent slopes	2,871	.11
Kukaiau silty clay loam, 12 to 20 percent slopes	5,301	.21
Kukaiau silty clay loam, 20 to 35 percent slopes	1,459	.06
Kukaiau silty clay loam, moderately shallow, 12 to 20 percent slopes	381	.01
Maile silt loam, 0 to 3 percent slopes	2,313	.09
Moaula silty clay loam, 0 to 10 percent slopes	2,000	.08
Moaula silty clay loam, 10 to 20 percent slopes	1,778	.07
Moaula silty clay loam, 20 to 35 percent slopes	732	.03
Naalehu silty clay loam, 0 to 10 percent slopes	1,444	.06
Naalehu silty clay loam, 10 to 20 percent slopes	1,105	.04
Naalehu silty clay loam, 20 to 35 percent slopes	814	.03
Naalehu very rocky silty clay loam, 6 to 20 percent slopes	1,569	.06
Niulii silty clay loam, 6 to 12 percent slopes	339	.01
Niulii silty clay loam, 12 to 20 percent slopes	1,227	.05
Niulii silty clay loam, 20 to 35 percent slopes	1,420	.06
Olaa silty clay loam, 0 to 10 percent slopes	2,821	.11
Olaa extremely stony silty clay loam, 0 to 20 percent slopes	5,828	.23
Ookala silty clay loam, 6 to 12 percent slopes	923	.04
Ookala silty clay loam, 12 to 20 percent slopes	2,730	.11
Ookala silty clay loam, 20 to 35 percent slopes	585	.02
HIGH INTENSITY SURVEY—Continued		
	Acres	*Percent*
Paauhau silty clay loam, 6 to 12 percent slopes	2,342	.09
Paauhau silty clay loam, 12 to 20 percent slopes	3,293	.13
Paauhau silty clay loam, 20 to 35 percent slopes	1,378	.05
Panaewa very rocky silty clay loam, 0 to 10 percent slopes	3,672	.14
Tropaquepts	704	.03
LOW-INTENSITY SURVEY		
Apakuie very fine sandy loam, 12 to 20 percent slopes	11,371	.44
Apakuie very stony very fine sandy loam, 12 to 20 percent slopes	24,350	.95
Beaches	308	.01
Fill land	472	.02
Hanipoe very stony loam, 12 to 20 percent slopes	16,819	.65
Hanipoe silt loam, 12 to 20 percent slopes	20,613	.80
Hanipoe very rocky silt loam, 6 to 20 percent slopes	2,182	.08
Heake very rocky sandy loam, 6 to 12 percent slopes	7,542	.29
Heake extremely rocky sandy loam, 0 to 10 slopes	468	.02
Honaunau silt loam, 6 to 20 percent slopes	1,684	.07
Honaunau extremely rocky silty clay loam, 6 to 20 percent slopes	3,014	.12
Honokaa silty clay loam, 10 to 20 percent slopes	24,157	.94
Honokaa silty clay loam, 20 to 35 percent slopes	738	.03
Honuaulu very stony silty clay loam, 6 to 20 percent slopes	1,258	.05
Honuaulu extremely stony silty clay loam, 12 to 20 percent slopes	3,923	.15
Kaalualu extremely stony loamy sand, 2 to 12 percent slopes	4,685	.18
Kahua silty clay loam, 6 to 20 percent slopes	9,968	.39
Kainaliu very stony silty clay loam, 12 to 20 percent slopes	530	.02
Kainaliu extremely stony silty clay loam, 12 to 20 percent slopes	2,799	.11
Kamakoa very fine sandy loam, 0 to 10 percent slopes	2,662	.10
Kamaoa loam, 6 to 12 percent slopes	1,130	.04
Kamaoa loam, moderately shallow, 6 to 12 percent slopes	1,525	.06
Kamaoa extremely stony loam, 6 to 12 percent slopes	404	.02
Kapapala loam, 0 to 10 percent slopes	1,007	.04
Kapapala loam, 10 to 20 percent slopes	1,885	.07
Kapapala very rocky loam, 6 to 20 percent slopes	2,119	.08
Kawaihae extremely stony very fine sandy loam, 6 to 12 percent slopes	22,106	.86
Kawaihae very rocky very fine sandy loam, 6 to 12 percent slopes	6,872	.27
Kealakekua silty clay loam, 12 to 20 percent slopes	1,665	.06
Kealakekua very stony silty clay loam, 6 to 20 percent slopes	800	.03
Kealakekua extremely stony silty clay loam, 12 to 20 percent slopes	2,884	.11
Keekee loamy sand, 0 to 6 percent slopes	5,103	.20

TABLE 1.—*Approximate acreage and proportionate extent of the soils*—Continued

Soil	Area	Extent
LOW-INTENSITY SURVEY—Continued		
	Acres	*Percent*
Kehena silty clay loam, 6 to 12 percent slopes	3, 265	. 13
Kikoni very fine sandy loam, 3 to 12 percent slopes	7, 575	. 29
Kikoni extremely stony very fine sandy loam, 6 to 12 percent slopes	1, 810	. 07
Kilohana loamy fine sand, 12 to 20 percent slopes	12, 860	. 50
Laumaia silt loam, 6 to 20 percent slopes	3, 771	. 15
Laumaia extremely stony silt loam, 6 to 12 percent slopes	5, 715	. 22
Mahukona silty clay loam, 3 to 12 percent slopes	482	. 02
Mahukona very stony silty clay loam, 6 to 12 percent slopes	2, 883	. 11
Maile silt loam, 6 to 20 percent slopes	25, 721	1. 00
Manahaa silt loam, 6 to 20 percent slopes	2, 113	. 08
Manahaa extremely stony silt loam, 6 to 20 percent slopes	5, 735	. 22
Mixed alluvial land	423	. 02
Ohia silty clay loam, 0 to 10 percent slopes	5, 928	. 23
Ohia extremely stony silty clay loam, 0 to 20 percent slopes	3, 696	. 14
Pakini very fine sandy loam, 2 to 6 percent slopes	6, 588	. 26
Palapalai silt loam, 6 to 12 percent slopes	5, 907	. 23
Palapalai silty clay loam, 6 to 12 percent slopes	1, 968	. 08
Piihonua silty clay loam, 6 to 20 percent slopes	25, 083	. 97
Piihonua extremely stony silty clay loam, 6 to 20 percent slopes	5, 603	. 22
Puaulu silt loam, 0 to 10 percent slopes	6, 242	. 24
Punohu silt loam, 12 to 20 percent slopes	5, 242	. 20
Puukala extremely stony silt loam, 6 to 12 percent slopes	10, 961	. 43
Puukala very rocky silt loam, 6 to 12 percent slopes	2, 220	. 09
Puu Oo silt loam, 6 to 12 percent slopes	12, 171	. 47
Puu Pa extremely stony very fine sandy loam, 6 to 20 percent slopes	39, 606	1. 54
Puu Pa extremely stony very fine sandy loam, 70 to 100 percent slopes, severely eroded	1, 972	. 08
Puu Pa silt loam, 12 to 20 percent slopes	306	. 01
Rough broken land	27, 392	1. 06
Umikoa silt loam, 12 to 20 percent slopes	10, 749	. 42
Umikoa extremely stony silt loam, 12 to 20 percent slopes	1, 005	. 03
Waiaha silt loam, 0 to 10 percent slopes	1, 379	. 05
Waiaha silt loam, 10 to 20 percent slopes	840	. 03
Waiaha extremely stony silt loam, 6 to 12 percent slopes	2, 144	. 08
Waiaha very rocky silt loam, 10 to 20 percent slopes	793	. 03
Waikaloa very fine sandy loam, 6 to 12 percent slopes	16, 856	. 65
Waimea very fine sandy loam, 6 to 12 percent slopes	22, 547	. 88
Waimea extremely stony very fine sandy loam, 12 to 20 percent slopes	12, 811	. 50
RECONNAISSANCE SURVEY		
Akaka soils	89, 961	3. 50
Amalu soils	12, 185	. 47
Amalu-Rough broken land association	11, 568	. 45
Cinder land	45, 991	1. 79
Huikau loamy sand, 12 to 20 percent slopes	2, 984	. 12
Huikau loamy sand, 12 to 20 percent slopes, eroded	3, 822	. 15
Huikau extremely stony loamy sand, 12 to 20 percent slopes	23, 363	. 91
Hydrandept-Tropofolist association	48, 528	1. 89
Kahaluu extremely rocky muck, 6 to 20 percent slopes	49, 165	1. 91
Kaimu extremely stony peat, 6 to 20 percent slopes	18, 374	. 71
Keaukaha extremely rocky muck, 6 to 20 percent slopes	24, 572	. 95
Keei extremely rocky muck, 6 to 20 percent slopes	87, 509	3. 40
Kekake extremely rocky muck, 6 to 20 percent slopes	104, 537	4. 06
Kilauea extremely gravelly sand, 6 to 12 percent slopes	11, 210	. 44
Kiloa extremely stony muck, 6 to 20 percent slopes	63, 551	2. 47
Kona extremely rocky muck, 6 to 20 percent slopes	25, 692	1. 00
Lalaau extremely stony muck, 6 to 20 percent slopes	16, 352	. 64
Lava flows, Aa	484, 315	18. 74
Lava flows, pahoehoe	547, 566	21. 15
Malama extremely stony muck, 3 to 15 percent slopes	12, 555	. 49
Manu silt loam, 2 to 6 percent slopes	2, 571	. 10
Mawae extremely stony muck, 6 to 20 percent slopes	48, 092	1. 87
Opihikao extremely rocky muck, 3 to 25 percent slopes	10, 369	. 40
Papai extremely stony muck, 3 to 25 percent slopes	21, 019	. 82
Puhimau silt loam, 2 to 6 percent slopes	3, 929	. 15
Puna extremely stony muck, 3 to 25 percent slopes	25, 213	. 98
Punaluu extremely rocky peat, 6 to 20 percent slopes	27, 131	1. 05
Rock land	29, 534	1. 15
Very stony land	75, 451	2. 93
Total	2, 579, 000	100. 00

to none. The depth to basic igneous rock ranges from 24 to 36 inches. In some areas at lower elevations, the B horizon is slightly compact.

Included with this soil in mapping are small, eroded knolls where the soils are shallow and rock fragments are common on the surface. Also included are small areas that have a slope of less than 3 percent.

Permeability is moderately rapid, runoff is slow, and the erosion hazard is slight. Roots can penetrate to a depth of 2 feet or more.

This soil is used for sugarcane, macadamia nuts, and homesites. (Capability subclass IIIe, nonirrigated; sugarcane group 3; pasture group 7; woodland group 5)

Ainakea silty clay loam, 12 to 20 percent slopes (AcD).—This soil is similar to Ainakea silty clay loam, 3 to 12 percent slopes, except that it is moderately steep.

Included in mapping are about 90 acres of cinder cones about 1 mile south of Hawi. These cinder cones have a slope of 50 to 90 percent. Their surface layer is

like that of the Ainakea soil but is underlain by cinders at a depth of 10 to 20 inches.

Runoff is medium, and the erosion hazard is moderate. This soil is used for sugarcane and macadamia nuts and as homesites. (Capability subclass IVe, nonirrigated; sugarcane group 3; pasture group 7; woodland group 5)

Ainakea silty clay loam, 20 to 35 percent slopes (AaE).—This soil is similar to Ainakea silty clay loam, 3 to 12 percent slopes, but is steep.

Included in mapping are small areas of shallow soils and stony soils.

Runoff is rapid, and the erosion hazard is severe. This soil is used for sugarcane, macadamia nuts, and pasture. (Capability subclass VIe, nonirrigated; sugarcane group 3; pasture group 7; woodland group 5)

Akaka Series

The Akaka series consists of moderately well drained silty clay loams that formed in volcanic ash. These are gently sloping to steep soils on uplands. They are at an elevation ranging from 1,000 to 4,500 feet. The annual rainfall is 150 to 300 inches, and it is well distributed throughout the year. The mean annual soil temperature is between 56° and 59° F. The natural vegetation consists of ohia, tree fern, koa, false staghorn fern, and amaumau fern. These soils are in the same general area as Honokaa, Kaiwiki, Kiloa, Lalaau, Ohia, and Piihonua soils.

Akaka soils are used for pasture, woodland, wildlife habitat, and watershed. Small acreages of sugarcane are grown in areas that are transitional to Kaiwiki soils.

Akaka silty clay loam, 0 to 10 percent slopes (AkC).—This gently undulating soil is on the windward side of Mauna Kea and Mauna Loa.

A representative profile has a surface layer of dark reddish-brown silty clay loam about 15 inches thick. The subsoil is reddish-brown to dark reddish-brown silty clay loam, and it is more than 57 inches thick. The surface layer is strongly acid, and the subsoil is strongly acid to medium acid. This soil dehydrates irreversibly into fine gravel-size aggregates.

Representative profile, Piihonua Quadrangle, lat. 19°44′52″ N. and long. 155°10′25″ W.:

A11—0 to 7 inches, dark reddish-brown (5YR 3/4) silty clay loam; moderate, medium and fine, subangular blocky structure; upper 2 inches almost massive; friable, slightly sticky, plastic, and moderately smeary; common roots; common fine and few coarse pores; common worm casts; strongly acid; clear, wavy boundary. (3 to 8 inches thick)

A12—7 to 15 inches, dark reddish-brown (5YR 3/4) silty clay loam; moderate, medium and fine, subangular blocky structure; friable, slightly sticky, plastic, and moderately smeary; few roots; common, coarse and medium pores; few, firm, gravel-size fragments of volcanic ash; strongly acid; gradual, wavy boundary. (2 to 8 inches thick)

B1—15 to 23 inches, reddish-brown (5YR 4/4) silty clay loam; few, coarse, faint mottles of dark brown (7.5YR 3/2) and reddish brown (2.5YR 4/4); moderate, medium and fine, subangular blocky structure; friable, slightly sticky, plastic, and moderately smeary; few roots; common medium and fine pores; thick, gelatinlike coatings on ped faces; strongly acid; gradual, wavy boundary. (6 to 8 inches thick)

B21—23 to 32 inches, dark reddish-brown (5YR 3/4) silty clay loam; common, coarse, faint mottles of reddish brown (2.5YR 4/4); moderate, medium, prismatic structure that breaks to strong, medium and fine, subangular blocky structure; friable, sticky, plastic, and strongly smeary; few roots; few coarse and many very fine pores; few gravel-size fragments of volcanic ash; strongly acid; abrupt, wavy boundary. (6 to 11 inches thick)

B22—32 to 38 inches, dark reddish-brown (2.5YR 3/4) silty clay loam with pockets of dark brown (7.5YR 3/2); weak, medium, prismatic structure; firm, slightly sticky, plastic, and strongly smeary; very few roots; common fine and very fine pores; many, fine, reddish-yellow (7.5YR 6/6) concretions; thick, gelatinlike coatings on peds; medium acid; abrupt, wavy boundary. (2 to 8 inches thick)

B23—38 to 48 inches, dark reddish-brown (5YR 3/4) silty clay loam with common, coarse, vertical streaks of reddish brown (5YR 4/4); moderate, medium, prismatic structure; firm, slightly sticky, plastic, and strongly smeary; very few roots; common fine pores; thick, gelatinlike coatings on ped faces; medium acid; clear, wavy boundary. (6 to 12 inches thick)

B24—48 to 52 inches, dark-red (2.5YR 3/6) silty clay loam; moderate, medium, prismatic structure; firm, slightly sticky, plastic, and strongly smeary; very few roots; common very fine pores with many, fine, reddish-yellow (7.5YR 6/6) concretions; some prism faces are smooth; medium acid; abrupt, wavy boundary. (4 to 8 inches thick)

B25—52 to 72 inches, dark reddish-brown (5YR 3/4) silty clay loam; moderate, medium, prismatic structure; friable, slightly sticky, plastic, and strongly smeary; occasional fine roots; common fine and very fine pores; thick, gelatinlike coatings on peds; few pressure cutans; few, fine, gravel-size gibbsite concretions.

The hue of the solum ranges from 2.5YR to 10YR. In some places, the B horizon has distinct mottles above bands of firm, cemented ash.

Included with this soil in mapping are small areas that are shallow over pahoehoe bedrock. These areas occupy less than 5 percent of the mapping unit. A few swampy areas less than an acre in size are also included.

Permeability is rapid, runoff is slow, and the erosion hazard is slight. Roots can penetrate to a depth of 5 feet or more.

This soil is used mainly for woodland and watershed. At the lower elevations sugarcane is grown in places. (Capability subclass IIIe, nonirrigated; sugarcane group 4; pasture group 8; woodland group 6)

Akaka silty clay loam, 10 to 20 percent slopes (AkD).—This soil is similar to Akaka silty clay loam, 0 to 10 percent slopes, but is moderately sloping. Runoff is medium, and the erosion hazard is moderate.

Included in mapping are small drainageways that have slopes steeper than 20 percent. Also included in the Kamaoa area are somewhat poorly drained soils that occupy less than 10 percent of this mapping unit.

This soil is used for sugarcane, pasture, woodland, and watershed. (Capability subclass IVe, nonirrigated; sugarcane group 4; pasture group 8; woodland group 6)

Akaka soils (rAK).—These soils are in the rain forest above the sugarcane fields. Their slope generally ranges from 3 to 20 percent, but they are dissected by many small drainageways, some of which have a slope of 40 or 50 percent.

Included in mapping are small, swampy areas of shallow soils underlain by pahoehoe bedrock.

Akaka soils are used for woodland, pasture, and watershed. (Capability subclass IVe, nonirrigated; pasture group 8; woodland group 6)

Alapai Series

The Alapai series consists of well-drained silty clay loams that formed in volcanic ash. These soils are nearly level to steep. They are on uplands at an elevation ranging from 1,600 to 2,300 feet. The annual rainfall is 80 to 100 inches, and the mean annual soil temperature is between 64° and 67° F. The natural vegetation consists of ohia, guava, hilograss, and californiagrass. These soils are in the same general area as the Moaula soils.

Alapai soils are used for sugarcane and as woodland.

Alapai silty clay loam, 0 to 10 percent slopes (AlC).—This soil is on the low leeward side of Mauna Loa. The slope is dominantly 5 percent.

In a representative profile the surface layer is very dark brown and dark reddish-brown silty clay loam about 15 inches thick. The subsoil is dark-brown and dark reddish-brown silty clay loam about 59 inches thick. The surface layer is very strongly acid, and the subsoil is slightly acid to neutral. This soil dehydrates irreversibly into fine gravel-size aggregates. It is extremely stony in places.

Representative profile, Naalehu Quadrangle, lat. 19°05′22″ N. and long. 155°36′32″ W.:

Ap1—0 to 7 inches, very dark brown (10YR 2/2) silty clay loam; moderate, fine and very fine, subangular blocky structure; friable, slightly sticky, and slightly plastic; common roots; common very fine pores; few olivine crystals less than 1 millimeter in diameter; few nodules of volcanic ash; very strongly acid; abrupt, wavy boundary. (5 to 9 inches thick)

Ap2—7 to 15 inches, dark reddish-brown (5YR 3/3) light silty clay loam; moderate, fine and very fine, subangular blocky structure; friable, slightly sticky, plastic, and weakly smeary; common roots; common very fine and fine pores; common patches of gelatinlike coatings on ped surfaces; medium acid; clear, wavy boundary. (6 to 11 inches thick)

B1—15 to 27 inches, dark-brown (7.5YR 3/2) and dark reddish-brown (5YR 3/3) silty clay loam; moderate, medium, subangular blocky structure that breaks to moderate, fine and very fine, subangular blocky structure; friable, slightly sticky, plastic, and weakly smeary; common roots; many very fine and fine pores; common firm to very firm fragments of volcanic ash 1 to 4 millimeters in diameter; common patches of gelatinlike coatings on ped surfaces; neutral; abrupt, wavy boundary. (9 to 14 inches thick)

B21—27 to 36 inches, dark reddish-brown (5YR 3/4) light silty clay loam; moderate, medium, subangular blocky structure breaking to moderate, fine and very fine, subangular blocky structure; friable, slightly sticky, plastic, and moderately smeary; few roots; many very fine and fine pores, common medium pores, and few coarse pores; few fragments of volcanic ash as in above horizon; smooth, gelatinlike coatings on ped surfaces; slightly acid; abrupt, smooth boundary. (6 to 9 inches thick)

B22—36 to 43 inches, dark-brown (7.5YR 3/4) and dark reddish-brown (5YR 3/4) light silty clay loam; moderate, fine and very fine, subangular blocky structure; friable, slightly sticky, plastic, and moderately smeary; few roots; many very fine and fine pores, common medium pores, and few coarse pores; few, fine, firm to very firm fragments of volcanic ash; smooth, gelatinlike coatings on ped surfaces; slightly acid; abrupt, smooth boundary. (6 to 8 inches thick)

B23—43 to 50 inches, dark reddish-brown (5YR 3/4) light silty clay loam; moderate, medium, subangular blocky structure that breaks to moderate, fine and very fine, subangular blocky structure; friable, slightly sticky, plastic, and moderately smeary; few roots; many very fine and fine pores, common medium pores, and few coarse pores; common firm and very firm fragments of volcanic ash up to 5 millimeters in size; common small pockets of dark-brown (7.5YR 3/3) silty clay loam; smooth, gelatinlike coatings on ped surfaces; neutral; abrupt, smooth boundary. (5 to 7 inches thick)

B24—50 to 57 inches, dark reddish-brown (5YR 3/4) and dark-brown (7.5YR 3/4) light silty clay loam; common gray and black specks; moderate, medium, subangular blocky structure that breaks to moderate, fine and very fine, subangular blocky structure; friable, slightly sticky, plastic, and moderately smeary; few roots; many very fine and fine pores, common medium pores, and few coarse pores; common firm and very firm fragments of ash up to 5 millimeters in diameter; smooth, gelatinlike coatings on ped surfaces; neutral; abrupt, smooth boundary. (6 to 7 inches thick)

B25—57 to 66 inches, bands of dark-brown (7.5YR 3/3), reddish-brown (5YR 4/4), and dark-brown (10YR 3/3) light silty clay loam; common, fine, dark reddish-brown (2.5YR 3/3) mottles; moderate, coarse and medium, subangular blocky structure that breaks to moderate, fine and very fine, subangular blocky structure; friable, slightly sticky, plastic, and strongly smeary; few scattered roots; many very fine and fine pores and common medium and coarse pores; thick, gelatinlike coatings on ped surfaces; neutral; abrupt, smooth boundary. (8 to 10 inches thick)

B26—66 to 74 inches, upper 4 inches consists of very firm, dark reddish-brown (2.5YR 2/4) volcanic ash; lower part is mottled, dark reddish-brown (2.5YR 3/4 and 5YR 3/4), dark-brown (7.5YR 4/4), strong-brown (7.5YR 4/6), and yellowish-brown (10YR 5/6) light silty clay loam; moderate, medium, subangular blocky structure that breaks to moderate, fine and very fine, subangular blocky structure; friable, slightly sticky, plastic, and strongly smeary; occasional roots; many very fine and fine pores and common medium pores; thick, gelatinlike coatings on ped surfaces; slightly acid.

The depth to bedrock ranges from 40 to more than 74 inches. This soil is always moist. The A horizon ranges from 5YR to 10YR in hue and from 2 to 3 in chroma and value. The B horizon ranges from 5YR to 10YR in hue and from 2 to 4 in chroma. The texture of the B horizon is silt loam to silty clay loam.

Included in mapping are small areas of Moaula soils and small stony areas.

Permeability is rapid, runoff is slow, and the erosion hazard is slight. Roots can penetrate to bedrock.

This soil is used for sugarcane and as woodland. (Capability subclass IIIe, nonirrigated; sugarcane group 4; pasture group 9; woodland group 7)

Alapai silty clay loam, 10 to 20 percent slopes (AlD).—This soil is similar to Alapai silty clay loam, 0 to 10 percent slopes, except that it is steeper. Runoff is medium, and the erosion hazard is moderate.

This soil is used for sugarcane and as woodland. (Capability subclass IVe, nonirrigated; sugarcane group 4; pasture group 9; woodland group 7)

Alapai silty clay loam, 20 to 35 percent slopes (AlE).—This soil is similar to Alapai silty clay loam, 0 to 10 percent slopes, except that it is steeper. Runoff is medium, and the erosion hazard is severe. In places the

surface layer and part of the subsoil have been removed as a result of plowing and water erosion.

This soil is used for sugarcane and as woodland. (Capability subclass VIe, nonirrigated; sugarcane group 4; pasture group 9; woodland group 7)

Alapai extremely stony silty clay loam, 10 to 20 percent slopes (ApD).—This soil is 20 to 30 inches deep over Aa lava. Stones cover 3 to 15 percent of the surface. Included in mapping are small areas of soil less than 20 inches deep over Aa or pahoehoe lava. These inclusions occupy less than 10 percent of this unit. Runoff is medium, and the erosion hazard is moderate.

This soil is used for pasture and as woodland. (Capability subclass VIIs, nonirrigated; pasture group 9; woodland group 7)

Amalu Series

The Amalu series consists of poorly drained, mucky soils that formed in volcanic ash, cinders, and basic igneous rock. These soils are near the summit of the Kohala Mountains at an elevation ranging from 2,000 to 5,500 feet. They are gently sloping to steep. The annual rainfall is 75 to more than 250 inches and is well distributed throughout the year. The mean annual soil temperature is between 55° and 58° F. The natural vegetation consists of ohia, tree fern, loa, hilograss, and ricegrass. These soils are in the same general area as Kahua and Kehena soils.

Amalu soils are used for watershed and as wildlife habitat.

Amalu soils (rAM).—These soils are near the summit of the Kohala Mountains.

In a representative profile a 2-inch mat of partly decomposed mosses, leaves, and twigs overlies a 5-inch layer of smeary, mucky silt loam. This is separated from the subsoil by a 4-inch layer of dark-gray clay loam. The subsoil is dark-brown silty clay loam about 16 inches thick. In the lower part there is a thin, discontinuous sheet of ironstone. The profile is extremely acid to very strongly acid.

Representative profile, Hawi Quadrangle, lat. 20°07′33″ N. and long. 155°45′07″ W.:

O1—7 to 5 inches, partly decomposed mosses, leaves, and twigs; abrupt, smooth boundary. (0 to 5 inches thick)

O2—5 inches to 0, dark-gray (10YR 4/1) mucky silt loam, massive; friable, slightly sticky, slightly plastic, and smeary; many roots; many very fine pores; extremely acid; abrupt, smooth boundary. (4 to 7 inches thick)

A2g—0 to 4 inches, dark-gray (10YR 4/1) clay loam; weak, fine, subangular blocky structure; friable, sticky, plastic, and smeary; many roots; common fine pores; extremely acid; abrupt, smooth boundary. (3 to 5 inches thick)

B2ir—4 to 20 inches, dark-brown (10YR 4/3), dark yellowish-brown (10YR 3/4), and very dark grayish-brown (10YR 3/2) silty clay loam; moderate, medium and fine, subangular blocky structure; friable, sticky, plastic, and smeary; many roots matted over rocks and a discontinuous sheet of ironstone ½ inch thick; common fine pores; very strongly acid; abrupt, smooth boundary. (10 to 16 inches thick)

IIR—20 inches, pahoehoe lava.

Where these soils are steepest, they are commonly shallowest and exhibit the least mottling. Mottling is most common, and the ironstone sheet is thickest, at the highest elevations. The depth to the ironstone sheet ranges from 15 to 20 inches. The hue of the B horizon ranges from 7.5YR to 10YR and the texture ranges from silty clay loam to clay.

Permeability is rapid above the ironstone sheet. Runoff is slow, and the erosion hazard is slight. Roots can penetrate to the ironstone sheet.

Included with these soils in mapping are small, shallow areas of moss peat over pahoehoe lava bedrock.

These soils are used for watershed and as wildlife habitat. (Capability subclass VIIw, nonirrigated)

Amalu-Rough broken land association (rAR).—This association is on the Kohala Mountains. About half of it is Amalu soils and half is Rough broken land. Amalu soils are on the narrow ridgetops. They are as described for the series. Rough broken land is on the sides of gulches and consists of steep, precipitous slopes, largely devoid of soil.

This association is used for watershed and as wildlife habitat. (Amalu soils: capability subclass VIIw, nonirrigated; Rough broken land: capability subclass VIIIe, nonirrigated)

Apakuie Series

The Apakuie series consists of well-drained very fine sandy loams that formed in volcanic ash, sand, and cinders. These are moderately sloping to steep soils on uplands. They are at an elevation ranging from 5,000 to 8,000 feet and receive from 20 to 35 inches of rainfall annually. In some years they are covered by snow for a few days. The mean annual soil temperature is between 50° and 53° F. The natural vegetation consists of koa, mamani, yorkshire fog, sweet vernal, Kentucky bluegrass, and heu pueo. These soils are in the same general area as Hanipoe, Huikau, Keekee, and Kilohana soils.

Apakuie soils are used for pasture and for wildlife habitat.

Apakuie very fine sandy loam, 12 to 20 percent slopes (AFD).—This soil is at high elevations on mountains.

In a representative profile the surface layer is about 15 inches thick and consists of dark reddish-brown and dusky-red loam and very fine sandy loam. The next layer is about 45 inches thick and consists of dark reddish-brown very fine sandy loam and loamy sand. This is underlain by volcanic sand, cinders, or fragmental Aa lava. This soil is neutral throughout the profile.

Representative profile, Umikoa Quadrangle, lat. 19°54′45″ N. and long. 155°23′30″ E.:

A11—0 to 2 inches, dark reddish-brown (5YR 2/2) loam; yellowish-brown (10YR 5/4) when dry; weak, fine, granular structure; friable, nonsticky, and nonplastic; many roots; many fine pores; neutral; abrupt, smooth boundary. (2 to 3 inches thick)

A12—2 to 8 inches, dusky-red (2.5YR 3/2) very fine sandy loam; dark reddish-gray (5YR 4/2) when dry; massive; friable, nonsticky, and nonplastic; many roots; few stones; many very fine pores; neutral; abrupt, wavy boundary. (4 to 7 inches thick)

A13—8 to 15 inches, dark reddish-brown (5YR 3/2) very fine sandy loam; yellowish brown (10YR 5/4) when dry; massive; friable, nonsticky, and nonplastic; common roots; many very fine pores; 5 percent of volume

consists of gravel larger than ¾ inch in diameter; neutral; clear, wavy boundary. (6 to 10 inches thick)

C1—15 to 30 inches, dark reddish-brown (5YR 3/3) very fine sandy loam; yellowish brown (10YR 5/6) when dry; massive; friable, nonsticky, and nonplastic; few roots; many very fine pores; 5 percent of volume consists of gravel larger than ¾ inch in diameter; neutral; gradual, wavy boundary. (10 to 20 inches thick)

C2—30 to 60 inches, dark reddish-brown (5YR 3/3) loamy sand; yellowish brown (10YR 5/6) when dry; weak, coarse, prismatic structure; friable, nonsticky, and nonplastic; few roots; many very fine pores; 10 percent of volume consists of gravel larger than ¾ inch in diameter; neutral.

The depth to bedrock ranges from 30 inches to more than 60 inches. The hue of the A horizon ranges from 2.5YR to 7.5YR. In places there are pockets of dark-red soils. The structure of the A horizon ranges from weak to moderate. The texture of the C horizon ranges from very fine sandy loam to loamy sand.

Included in mapping are small areas where considerable soil blowing has occurred and the vegetation is sparse. Small stony areas are also included.

Permeability is rapid, and runoff is slow. The hazard of soil blowing is moderate. Roots can penetrate to a depth of 3 feet or more.

This soil is used for pasture and wildlife habitat. (Capability subclass VIe, nonirrigated; pasture group 14; woodland group 16)

Apakuie very stony very fine sandy loam, 12 to 20 percent slopes (ASD).—This soil is similar to Apakuie very fine sandy loam, 12 to 20 percent slopes, except that loose stones occupy about 3 percent of the surface. The depth to Aa lava averages 30 inches.

This soil is used for pasture and for wildlife habitat. (Capability subclass VIs, nonirrigated; pasture group 14; woodland group 16)

Beaches

Beaches (BH) are mapped as a land type. They are long, narrow, sloping areas of sand and gravel along the coastline of the island. The sand and gravel vary in color according to the material in which they formed. The yellowish or white sand formed in coral and sea shells, the black sand formed in lava rocks, and the green sand formed in olivine. The annual rainfall is 5 to 80 inches. The mean annual soil temperature is 72° to 75° F.

Beaches are used for recreation. They are sometimes covered by waves during storms or high tide. (Capability subclass VIIIw, nonirrigated)

Cinder Land

Cinder land (rCL) is a miscellaneous land type consisting of bedded cinders, pumice, and ash. These materials are black, red, yellow, brown, or variegated. The particles have jagged edges and a glassy appearance and show little or no evidence of soil development.

Cinder land commonly supports some grass, but it is not good pastureland because of its loose consistency and poor trafficability. This land is a source of material for surfacing roads. (Capability subclass VIIIs, nonirrigated)

Fill Land

Fill land (FL) is a miscellaneous land type on flats near Pahala. This land is a mixture of the waste from sugarcane mills and alluvium from floodwaters.

The vegetation consists of feather fingergrass, bristly foxtail, kiawe, and guineagrass. The elevation ranges from near sea level to 500 feet, and the annual rainfall is 10 to 40 inches. The mean annual soil temperature is between 72° and 74° F. Fill land is in the same general area as Punaluu soils and pahoehoe lava flows.

This land is well drained. It is slowly permeable, has medium runoff, and has a slight erosion hazard. It is used for pasture. (Capability subclass IIe, irrigated, and IVs, nonirrigated; pasture group 2)

Hanipoe Series

The Hanipoe series consists of well-drained silt loams that formed in volcanic ash. These soils are gently sloping to steep. They are on uplands at an elevation ranging from 5,000 to 6,500 feet. They receive from 30 to 50 inches of rainfall annually, and their mean annual soil temperature is between 50° and 53° F. The natural vegetation consists of koa, puu lehua, yorkshire fog, sweet vernal, and rattailgrass. These soils are in the same general area as Apakuie, Kapapala, Laumaia, Manahaa, Punohu, and Umikoa soils.

Hanipoe soils are used for pasture, woodland, and orchards and for wildlife habitat (fig. 5).

Hanipoe silt loam, 12 to 20 percent slopes (HDD).—This rolling soil occupies high mountain slopes.

A representative profile has a surface layer of dark reddish-brown to very dark brown silt loam about 10 inches thick. In many places this layer is underlain by a thin, discontinuous, red layer of material having the texture of sandy loam. The subsoil is dark-brown and dark reddish-brown silt loam about 50 inches thick. The surface layer is slightly acid; the subsoil is neutral. In places this soil is very rocky. In other places it is very stony and is only 20 to 30 inches deep over bedrock.

Representative profile, Umikoa Quadrangle, lat. 19°56′20″ N. and long. 155°23′47″ W.:

A11—0 to 5 inches, dark reddish-brown (5YR 2/2) silt loam; weak, fine, granular structure; soft, friable, nonsticky, and slightly plastic; many roots; many very fine pores; slightly acid; abrupt, smooth boundary. (4 to 6 inches thick)

A12—5 to 10 inches, very dark brown (10YR 2/2) silt loam; weak, very fine, granular structure; soft, friable, nonsticky, and slightly plastic; many roots; many very fine pores; slightly acid; abrupt, wavy boundary. (4 to 6 inches thick)

B21—10 to 18 inches, dark-brown (7.5YR 3/4) silt loam; weak, medium and fine, subangular blocky structure; slightly hard, friable, slightly sticky, and slightly plastic; many roots; many fine pores; neutral; gradual, wavy boundary. (6 to 10 inches thick)

B22—18 to 31 inches, dark reddish-brown (5YR 3/3) silt loam; weak, medium and coarse, subangular blocky structure; slightly hard, friable, slightly sticky, and slightly plastic; many roots; many very fine pores; neutral; abrupt, smooth boundary. (10 to 15 inches thick)

B23—31 to 43 inches, dark-brown (10YR 3/3) silt loam; weak, medium, subangular blocky structure; slightly

Figure 5.—Koa and ohia trees and kikuyugrass growing on Hanipoe soils.

hard, friable, slightly sticky, and plastic; many roots; many fine pores; neutral; abrupt, wavy boundary. (10 to 12 inches thick)

B24—43 to 60 inches, dark-brown (7.5YR 3/3) silt loam; weak, medium, subangular blocky structure; slightly hard, friable, slightly sticky, and plastic; many roots; many very fine pores; neutral.

The A horizon ranges from very fine sandy loam to silt loam in texture, from 5YR to 10YR in hue, and from weak to moderate granular in structure. In places there is a thin, massive, red layer in or immediately below the A horizon. This layer has the texture of sandy loam. The B horizon ranges from silt loam to very fine sandy loam in texture and has a massive to weak, subangular blocky structure.

Included in mapping are a few stony areas and rock outcrops, mainly on ridges and steep knolls. A few cinder cones are also included.

Permeability is moderately rapid, runoff is medium, and the erosion hazard is moderate. Roots can penetrate to a depth of 5 feet or more.

This soil is used for pastureland, woodland, and orchards, and for wildlife habitat. (Capability subclass IVe, nonirrigated; pasture group 13; woodland group 10)

Hanipoe very rocky silt loam, 6 to 20 percent slopes (HFD).—This soil is similar to Hanipoe silt loam, 12 to 20 percent slopes, except that rock outcrops and loose stones occupy 10 to 25 percent of the surface area. The depth to bedrock is about 30 inches.

This soil is used for pasture and for wildlife habitat. (Capability subclass VIs, nonirrigated; pasture group 13; woodland group 10)

Hanipoe very stony loam, 12 to 20 percent slopes (HCD).—This soil is only 20 to 30 inches deep over fragmental Aa lava. Runoff is slow, and the erosion hazard is slight.

This soil is used for pasture and woodland and for wildlife habitat. (Capability subclass VIs, nonirrigated; pasture group 13; woodland group 10)

Hawi Series

The Hawi series consists of well-drained silty clays that formed in basic igneous rocks and were influenced by volcanic ash. These are nearly level to moderately sloping soils on uplands. They are at an elevation ranging from near sea level to 1,200 feet and receive 25 to 40 inches of rainfall annually, mostly during the winter months. Their mean annual soil temperature is between 72° and 75° F. The natural vegetation consists

of lantana, uhaloa, ilima, natal redtop, and bermudagrass. These soils are in the same general area as Kohala and Mahukona soils.

Hawi soils are used for pasture and irrigated sugarcane.

Hawi silty clay, 0 to 3 percent slopes (HaA).—This soil is on the lower parts of the Kohala Mountains.

In a representative profile the surface layer is very dark grayish-brown silty clay about 15 inches thick. The subsoil is very dark grayish-brown to dark yellowish-brown stony silty clay about 53 inches thick. The substratum is soft, weathered basic igneous rock. The surface layer is slightly acid, and the subsoil is neutral. The surface is extremely stony in places.

Representative profile, Hawi Quadrangle, lat. 20°15′53″ N. and long. 155°52′28″ W.:

Ap—0 to 15 inches, very dark grayish-brown (10YR 3/2) silty clay; dark brown (10YR 4/3) when dry; strong, fine, granular structure; friable, very hard, sticky, and very plastic; many roots; many fine and very fine pores; violent effervescence with hydrogen peroxide; slightly acid; abrupt, smooth boundary. (7 to 15 inches thick)

B21—15 to 30 inches, very dark grayish-brown (10YR 3/2) silty clay; moderate, coarse, subangular blocky structure; firm, very hard, sticky, and very plastic; common roots; many very fine pores; many, very fine, black specks; strong effervescence with hydrogen peroxide; slightly acid; abrupt, smooth boundary. (10 to 15 inches thick)

B22—30 to 48 inches, dark yellowish-brown (10YR 3/4) and dark-brown (10YR 3/3) stony silty clay; moderate, fine, subangular blocky structure; firm, very hard, sticky, and very plastic; common roots; many fine pores; many, very fine, black specks; strong effervescence with hydrogen peroxide; stone-size basalt fragments make up 10 percent of the horizon; neutral; abrupt, smooth boundary. (10 to 20 inches thick)

B23—48 to 68 inches, dark-brown (10YR 3/3) stony silty clay; weak, medium, subangular blocky structure; firm, very hard, sticky, and plastic; few roots; many very fine pores; few black specks; strong effervescence with hydrogen peroxide; stone-size basalt fragments make up about 20 percent of the horizon; neutral.

The hue of the solum ranges from 7.5YR to 10YR, and the texture from silty clay to silty clay loam. The structure of the A horizon ranges from moderate to strong granular.

Permeability is moderate, runoff is slow, and the erosion hazard is slight. The available water capacity is about 1.5 inches per foot of soil. Roots can penetrate to a depth of 4 feet or more.

This soil is used for irrigated sugarcane. (Capability class I, irrigated, and capability subclass IIc, nonirrigated; sugarcane group 1; pasture group 3)

Hawi silty clay, 3 to 12 percent slopes (HaC).—This soil is similar to Hawi silty clay, 0 to 3 percent slopes, except that it is moderately sloping. Runoff is medium, and the erosion hazard is moderate.

This soil is used for irrigated sugarcane and for pasture. (Capability subclass IIIe, irrigated, and IIIe, nonirrigated; sugarcane group 1; pasture group 3)

Hawi extremely stony silty clay, 6 to 12 percent slopes (HeC).—This soil is similar to Hawi silt loam, 0 to 3 percent slopes, except that stones cover 3 to 15 percent of its surface, and it is moderately sloping. Runoff is medium, and the erosion hazard is moderate.

This soil is used for pasture. (Capability subclass VIIs, nonirrigated; pasture group 3)

Heake Series

The Heake series consists of well-drained sandy loams that formed in recent volcanic ash and pumice. These soils are gently sloping to moderately sloping. They are on uplands at an elevation ranging from 2,000 to 4,000 feet and receive from 60 to 90 inches of rainfall annually. Their mean annual soil temperature is between 59° and 61° F. The natural vegetation consists of ohia, ohelo berry, puakeawe, and carpetgrass. These soils are in the same general area as Kilauea, Manu, Puaulu, and Puhimau soils.

Heake soils are used for pasture, woodland, wildlife habitat, and recreation areas. Most of the acreage is in the Hawaii Volcanoes National Park.

Heake very rocky sandy loam, 6 to 12 percent slopes (HHC).—This moderately sloping soil is on the south side of Mauna Loa near the Kilauea Crater. Outcrops of pahoehoe lava occupy 10 to 30 percent of the surface area.

In a representative profile the surface layer is about 5 inches thick and consists of very dark brown to very dark grayish-brown sandy loam and fine sand. The next layer consists of dark grayish-brown to very dark grayish-brown fine sand and pumice extending to a depth of about 17 inches. The underlying material is pahoehoe lava bedrock. The upper part of the surface layer is medium acid. The rest of the profile is neutral.

Representative profile, Kilauea Quadrangle, lat. 19°26′18″ N. and long. 155°17′38″ W.:

A11—0 to 2 inches, very dark brown (7.5YR 2/2) sandy loam; dark brown (7.5YR 4/2) when dry; weak, very fine, granular structure; soft, friable, nonsticky, and nonplastic; common roots; many very fine pores; common very fine and fine basalt fragments; medium acid; abrupt, smooth boundary. (2 to 4 inches thick)

A12—2 to 5 inches, very dark grayish-brown (10YR 3/2 and 2.5Y 3/2) fine sand; grayish brown (2.5Y 5/2) when dry; single grain; loose, nonsticky, and nonplastic; few roots; many pores; neutral; abrupt, smooth boundary. (2 to 5 inches thick)

IIC1—5 to 9 inches, dark grayish-brown (10YR 4/2) and dark-brown (7.5YR 3/2) loam; grayish brown (2.5Y 5/2) when dry; weak, fine, subangular blocky structure; soft, friable, nonsticky, and nonplastic; few roots; many pores; common basalt fragments 2 to 10 millimeters in diameter; neutral; abrupt, smooth boundary. (3 to 5 inches thick)

IIIC2—9 to 12 inches, very dark grayish-brown (2.5Y 3/2) fine sand; light brownish gray (2.5Y 6/2) when dry; weak, medium, platy structure; hard, firm, nonsticky, and nonplastic; compact in place; many very fine pores; few roots matted between platy aggregates; neutral; abrupt, wavy boundary. (2 to 5 inches thick)

IVC3—12 to 17 inches, very dark grayish-brown (10YR 3/2) pumice and pockets of dark-brown (10YR 3/3), weathered pumice; dark grayish brown (2.5Y 4/2) when dry; massive; few roots; neutral; abrupt, smooth boundary. (4 to 7 inches thick)

VR—17 inches, pahoehoe lava.

The depth to pahoehoe lava bedrock ranges from 13 to 20 inches. The texture of the A11 horizon ranges from sandy loam to loam, and the structure ranges from weak, granular to platy. The texture of the C1 horizon ranges from fine sand to loam. The glassy pumice layer is very thin in some areas.

Included in mapping are small areas of nonstony soil.

Permeability is rapid, runoff is medium, and the erosion hazard is moderate. Roots can penetrate to bedrock.

This soil is used for pasture and woodland and for wildlife habitat. The major part of it is in the Hawaii Volcanoes National Park. (Capability subclass VIs, nonirrigated; pasture group 10; woodland group 11)

Heake extremely rocky sandy loam, 0 to 10 percent slopes (HKC).—This soil is similar to Heake very rocky sandy loam, 6 to 12 percent slopes, except that 25 to 50 percent of the area consists of rock outcrops. Runoff is slow and the erosion hazard is slight.

This soil is used for pasture, wildlife habitat, and recreation areas. (Capability subclass VIIs, nonirrigated; pasture group 10; woodland group 11)

Hilea Series

The Hilea series consists of well-drained silty clay loams that formed in volcanic ash. These are gently sloping to moderately sloping soils on uplands. They are at an elevation of 900 to 2,000 feet and receive from 125 to 200 inches of rainfall annually. The mean annual soil temperature is between 65° and 67° F. The natural vegetation consists of ohia, tree fern, pamakani, glenwoodgrass, and ricegrass. These soils are in the same general area as Ohia, Olaa, and Panaewa soils.

Hilea soils are used for sugarcane and pasture and as woodland.

Hilea silty clay loam, 6 to 12 percent slopes (HIC).—This soil is low on the windward side of Mauna Loa.

In a representative profile the surface layer is very dark grayish-brown silty clay loam about 8 inches thick. The subsoil is dark-brown silty clay loam about 11 inches thick. Pahoehoe lava bedrock is at a depth of about 19 inches. The surface layer is very strongly acid, and the subsoil is strongly acid. This soil dehydrates irreversibly into gravel-size aggregates.

Representative profile, Mountain View Quadrangle, lat. 19°34′25″ N. and long. 155°06′50″ W.:

A1—0 to 8 inches, very dark grayish-brown (10YR 3/2) silty clay loam; strong, medium and fine, subangular blocky structure; friable, slightly sticky, plastic, and strongly smeary; many roots; many medium and fine pores; thin O2 horizon less than one-half inch thick on surface; a few stones on surface; very strongly acid; abrupt, smooth boundary. (6 to 12 inches thick)

B2—8 to 19 inches, dark-brown (7.5YR 3/3) silty clay loam; moderate, medium and fine, subangular blocky structure; friable, sticky, plastic, and strongly smeary; many roots; many fine and very fine pores; thick, gelatinlike coatings on ped surfaces; strongly acid; abrupt, wavy boundary. (10 to 15 inches thick)

IIR—19 inches, hard pahoehoe lava.

This soil is always moist. The depth of pahoehoe lava bedrock ranges from 16 to 20 inches. The hue of the solum ranges from 5YR to 10YR.

Included with this soil in mapping are small areas of Ohia and Kiloa soils.

Permeability is rapid, runoff is medium, and the erosion hazard is slight. Roots can penetrate to bedrock.

This soil is used for sugarcane and pasture and as woodland. (Capability subclass IVs, nonirrigated; sugarcane group 4; pasture group 9; woodland group 12)

Hilo Series

The Hilo series consists of well-drained silty clay loams. These soils formed in a series of volcanic ash layers that give them a banded appearance. They are gently sloping to steep soils on uplands at an elevation ranging from near sea level to 800 feet. They receive from 120 to 180 inches of rainfall annually, and their mean annual soil temperature is between 72° and 74° F. The natural vegetation consists of hilograss, californiagrass, guava, ohia, and tree fern. These soils are in the same general area as Kaiwiki, Olaa, and Ookala soils.

Hilo soils are used for sugarcane, truck crops, orchards, and pasture.

Hilo silty clay loam, 0 to 10 percent slopes (HoC).—This soil is low on the windward side of Mauna Kea and is dissected by deep, narrow gulches.

In a representative profile the surface layer is dark-brown silty clay loam about 12 inches thick. The subsoil is about 48 inches thick and consists of dark-brown, dark reddish-brown, and very dark grayish-brown silty clay loam. The surface layer is very strongly acid, and the subsoil is strongly acid to medium acid. This soil dehydrates irreversibly into fine gravel-size aggregates.

Representative profile, Honomu Quadrangle, lat. 19°46′50″ N. and long. 155°05′45″ W.:

Ap—0 to 12 inches, dark-brown (10YR 3/3) silty clay loam; strong, fine, subangular blocky structure; friable, slightly sticky, and plastic; many roots; many medium and fine pores; very strongly acid; abrupt, smooth boundary. (10 to 13 inches thick)

B21—12 to 22 inches, dark-brown (7.5YR 3/2) silty clay loam; moderate, medium, prismatic structure that breaks to moderate, medium and fine, subangular blocky structure; hard, friable, slightly sticky, plastic, and moderately smeary; many roots; many fine and very fine pores; many, fine, sugarlike coatings; strongly acid; clear, smooth boundary. (10 to 12 inches thick)

B22—22 to 31 inches, dark reddish-brown (5YR 3/4) silty clay loam; moderate, medium, prismatic structure that breaks to strong, medium and fine, subangular blocky structure; extremely hard, friable, slightly sticky, plastic, and moderately smeary; many roots; many medium and fine pores; many, fine, sugarlike coatings; medium acid; abrupt, smooth boundary. (7 to 10 inches thick)

B23—31 to 34 inches, very dark grayish-brown (10YR 3/2) silty clay loam; strong, medium, prismatic structure that breaks to strong, medium, subangular blocky structure; extremely hard, firm, slightly sticky, plastic, and moderately smeary; common roots; many medium and fine pores; few hard ash nodules; medium acid; abrupt, smooth boundary. (2 to 3 inches thick)

B24—34 to 42 inches, dark-brown (7.5YR 3/4) and dark reddish-brown (5YR 3/4) silty clay loam; moderate, medium, prismatic structure that breaks to strong, medium and fine, subangular blocky structure; extremely hard, friable, slightly sticky, plastic, and strongly smeary; few roots; many medium and fine pores; medium acid; abrupt, smooth boundary. (8 to 11 inches thick)

B25—42 to 46 inches, dark-brown (7.5YR 3/4) silty clay loam; moderate, medium, prismatic structure that breaks to strong, fine, subangular blocky structure; extremely hard, friable, sticky, plastic, and smeary; few roots; many coarse to very fine pores; medium acid; abrupt, smooth boundary. (4 to 11 inches thick)

B26—46 to 60 inches, dark-brown (7.5YR 3/4) silty clay loam; moderate, fine, prismatic structure that breaks

to strong, fine, subangular blocky structure; extremely hard, friable, sticky, plastic, and smeary; few roots; many fine and medium pores; medium acid.

The depth to bedrock is more than 5 feet. The B horizon, when moist, ranges from 5YR to 10YR in hue and from 2 to 4 in chroma.

Included in mapping are small areas of shallow soils over pahoehoe lava bedrock.

Permeability is rapid, runoff is slow, and the erosion hazard is slight. Roots can penetrate to a depth of 5 feet or more.

This soil is used mostly for sugarcane. Small areas are in truck crops, orchards, and pasture. (Capability subclass IIIe, nonirrigated; sugarcane group 2; pasture group 9; woodland group 7)

Hilo silty clay loam, 10 to 20 percent slopes (HoD).—This soil is similar to Hilo silty clay loam, 0 to 10 percent slopes, but is steeper. Runoff is medium, and the erosion hazard is slight to moderate.

This soil is used for sugarcane. (Capability subclass IVe, nonirrigated; sugarcane group 2; pasture group 9; woodland group 7)

Hilo silty clay loam, 20 to 35 percent slopes (HoE).—This soil is similar to Hilo silty clay loam, 0 to 10 percent slopes, but is steeper. Runoff is medium and the erosion hazard is moderate.

Most of this soil is used for sugarcane. Small areas are used for pasture. (Capability subclass VIe, nonirrigated; sugarcane group 2; pasture group 9; woodland group 7)

Honaunau Series

The Honaunau series consists of moderately well-drained silt loams that formed in volcanic ash. These are gently sloping to moderately steep soils on uplands at an elevation ranging from 3,000 to 5,000 feet. They receive from 90 to 150 inches of rainfall annually, mostly during the summer months. The mean annual soil temperature is between 62° and 65° F. The natural vegetation consists of ohia, koa, tree fern, and alapaio fern. These soils are in the same general area as Kealakekua, Keei, Kekake, Kiloa, and Manahaa soils.

Honaunau soils are used for pasture and woodland and for wildlife habitat.

Honaunau silt loam, 6 to 20 percent slopes (HND).—This soil is at intermediate elevations on the leeward side of Mauna Loa.

A representative profile has a surface layer of very dark brown silt loam about 6 inches thick. The subsoil is dark-brown to dark reddish-brown silt loam about 20 inches thick. It is mottled in the lower part. Pahoehoe lava bedrock is at a depth of about 26 inches. This soil is medium acid in the surface layer and slightly acid in the subsoil. It dehydrates irreversibly into fine gravel-size aggregates.

Representative profile, Kealakekua Quadrangle, lat. 19°29′38″ N. and long. 155°51′39″ W.:

A1—0 to 6 inches, very dark brown (7.5YR 2/2) silt loam; very dark brown (10YR 2/2) when dry; moderate, medium and fine, subangular blocky structure; slightly hard, friable, sticky, and plastic; many roots matted in upper 2 inches; many very fine pores; medium acid; clear, wavy boundary. (5 to 7 inches thick)

B21—6 to 12 inches, dark-brown (7.5YR 3/2) silt loam; very dark brown (7.5YR 2/2) when dry; weak, fine and very fine, subangular blocky structure; slightly hard, friable, slightly sticky, slightly plastic, and weakly smeary; many roots; many very fine pores; medium acid; clear, wavy boundary. (4 to 8 inches thick)

B22—12 to 18 inches, dark-brown (7.5YR 3/3) silt loam; dark brown (10YR 3/3) when dry; weak, fine and very fine, subangular blocky structure; hard, friable, slightly sticky, slightly plastic, and weakly smeary; many roots; many very fine and fine pores; thin, gelatinlike coatings; medium acid; clear, wavy boundary. (5 to 9 inches thick)

B23—18 to 26 inches, dark reddish-brown (5YR 3/4) silt loam; few, fine, faint, reddish-brown (5YR 4/3) and yellowish-red (5YR 4/6) mottles; dark brown (7.5YR 4/4) when dry; weak, fine and very fine, subangular blocky structure; hard, friable, slightly sticky, slightly plastic, and moderately smeary; few roots; many very fine pores; thick, gelatinlike coatings; slightly acid; abrupt, wavy boundary. (6 to 9 inches thick)

IIR—26 inches, pahoehoe lava.

The depth to pahoehoe lava bedrock ranges from 20 to 30 inches. Immediately below the A horizon in some places, there is a dusky-red, discontinuous layer that is loam in texture but has enough sand to feel gritty. The A1 horizon has weak to moderate structure. The B horizon is weakly smeary to smeary. The hue of the solum ranges from 5YR to 10YR.

Included in mapping are small areas of soils less than 20 inches deep over pahoehoe lava bedrock. Also included are small, stony areas and rock outcrops.

Permeability is rapid. Runoff is slow, and the erosion hazard is slight. Roots can penetrate to bedrock. This soil is used for pasture and woodland and for wildlife habitat. (Capability subclass IVe, nonirrigated; pasture group 9; woodland group 7)

Honaunau extremely rocky silty clay loam, 6 to 20 percent slopes (HRD).—Rock outcrops occupy 25 to 50 percent of the surface of this soil. Included in mapping are small areas less than 20 inches deep over pahoehoe lava bedrock.

This soil is used for pasture and for wildlife habitat. (Capability subclass VIIs, nonirrigated; pasture group 9)

Honokaa Series

The Honokaa series consists of well-drained silty clay loams that formed in volcanic ash. These are gently sloping to steep soils on uplands at an elevation ranging from 1,000 to 3,000 feet. They receive from 100 to 150 inches of rainfall annually, and their mean annual soil temperature is between 66° and 69° F. The natural vegetation consists of guava, ohia, kikuyugrass, hilograss, and broomsedge. These soils are in the same general area as Akaka, Kaiwiki, Kukaiau, Maile, and Ookala soils.

Honokaa soils are used mostly for sugarcane, pasture, and woodland. Small areas are used for truck crops and orchards.

Honokaa silty clay loam, 10 to 20 percent slopes (HTD).—This soil is low on the windward side of Mauna Kea.

In a representative profile the surface layer is dark-brown silty clay loam about 6 inches thick. The subsoil also is silty clay loam. It is dark brown, very dark brown, and very dark grayish brown and is about

59 inches thick. This soil is medium acid to slightly acid throughout the profile. It dehydrates irreversibly into fine gravel-size aggregates.

Representative profile, Honokaa Quadrangle, lat. 20°02′38″ N. and long. 155°26′48″ W.:

Ap—0 to 6 inches, dark-brown (7.5YR 3/2) silty clay loam; strong, fine and medium, subangular blocky structure; friable, sticky, and plastic; many roots; many fine and medium pores; medium acid; abrupt, smooth boundary. (5 to 7 inches thick)

B21—6 to 21 inches, dark-brown (7.5YR 3/4 and 3/2) silty clay loam; peds crush to a slightly stronger chroma; moderate, very fine and fine, subangular blocky structure; friable, sticky, plastic, and weakly smeary; many roots; many very fine and fine pores and common medium pores; gelatinous globular coatings of stronger chroma, and few, dull, patchy coatings on peds; medium acid; abrupt, smooth boundary. (15 to 16 inches thick)

B22—21 to 27 inches, very dark brown (7.5YR 2/3) and dark-brown (7.5YR 3/3) silty clay loam; strong, very fine and fine, subangular blocky structure; friable, sticky, plastic, and weakly smeary; many roots; many very fine and fine pores; gelatinous, globular coatings of stronger chroma on peds; slightly acid; abrupt, wavy boundary. (4 to 6 inches thick)

B23—27 to 32 inches, very dark grayish-brown (10YR 3/2) silty clay loam; strong, very fine and fine, subangular blocky structure; friable, sticky, plastic, and weakly smeary; many roots; many very fine and fine pores and few medium and coarse pores; common, dull, gelatinous coatings on peds; medium acid; abrupt, wavy boundary. (3 to 5 inches thick)

IIC—32 to 35 inches, dark reddish-brown (2.5YR 3/4) firm, cemented ash mixed with friable, weathered volcanic ash; moderately smeary; few roots; many very fine and fine pores and common medium and coarse pores; ash coated with amber-colored, gelatinous material; slightly acid; abrupt, smooth boundary. (3 to 4 inches thick)

IIIB21b—35 to 39 inches, dark-brown (10YR 3/3) silty clay loam; moderate, very fine and fine, subangular blocky structure and pockets of strong, fine, subangular blocky structure; friable, sticky, plastic, and weakly smeary; many roots; many very fine and fine pores; patchy, dull, gelatinous coatings on peds; slightly acid; abrupt, smooth boundary. (4 to 5 inches thick)

IIIB22b—39 to 44 inches, dark-brown (7.5YR 3/4) silty clay loam; strong, very fine and fine, subangular blocky structure; friable, sticky, plastic, and moderately smeary; many roots; many very fine and fine pores and common medium pores; thick, gelatinous coatings on peds; medium acid; abrupt, smooth boundary. (4 to 5 inches thick)

IIIB23b—44 to 57 inches, banded, dark-brown (10YR 3/3 and 7.5YR 3/4) silty clay loam; strong, very fine and fine, subangular blocky structure; friable, sticky, plastic, and moderately smeary; many roots; many very fine and fine pores and common medium pores; thick gelatinous coatings on peds; medium acid; abrupt, smooth boundary. (11 to 13 inches thick)

IIIB24b—57 to 65 inches, banded, yellowish-brown (10YR 5/4) and dark-brown (7.5YR 4/4) silty clay loam; strong, very fine and fine, subangular blocky structure; firm, sticky, plastic, and moderately smeary; common roots; common very fine pores; medium acid.

The A horizon ranges from 7.5YR to 10YR in hue. The B21 horizon has weak to moderate, subangular blocky structure. The B horizon is weakly smeary to moderately smeary and dehydrates irreversibly into fine gravel-size aggregates.

Included in mapping are small areas of Kaiwiki and Kahua soils.

Permeability is rapid, runoff is slow, and the erosion hazard is slight. Roots can penetrate to a depth of 5 feet or more.

This soil is used mostly for pasture and woodland. A small acreage at the lowest elevation is used for sugarcane. (Capability subclass IVe, nonirrigated; pasture group 9; woodland group 7)

Honokaa silty clay loam, 20 to 35 percent slopes (HTE).—This soil is similar to Honokaa silty clay loam, 10 to 20 percent slopes, except that it is steep. Runoff is medium, and the erosion hazard is moderate.

This soil is used mostly for pasture and woodland. A small acreage at the lowest elevation is used for sugarcane. (Capability subclass VIe, nonirrigated; pasture group 9; woodland group 7)

Honokaa silty clay loam, low elevation, 0 to 10 percent slopes (HsC).—This soil is similar to Honokaa silty clay loam, 10 to 20 percent slopes, except that it is gently sloping and occurs at a lower elevation where the soil temperature is warmer.

This soil is used mostly for sugarcane. Small areas are used for pasture and macadamia nuts. (Capability subclass IIIe, nonirrigated; sugarcane group 4; pasture group 9; woodland group 7)

Honokaa silty clay loam, low elevation, 10 to 20 percent slopes (HsD).—This soil is similar to Honokaa silty clay loam, 10 to 20 percent slopes, except that it occurs at a lower elevation where the soil temperature is warmer.

This soil is used principally for sugarcane. Small areas are used for pasture and macadamia nuts. (Capability subclass IVe, nonirrigated; sugarcane group 4; pasture group 9; woodland group 7)

Honokaa silty clay loam, low elevation, 20 to 35 percent slopes (HsE).—This soil is similar to Honokaa silty clay loam, 10 to 20 percent slopes, except that it is steep and occurs at a lower elevation where the soil temperature is warmer. Runoff is medium, and the erosion hazard is moderate.

This soil is used mostly for sugarcane. Small areas are used for pasture and macadamia nuts. (Capability subclass VIe, nonirrigated; sugarcane group 4; pasture group 9; woodland group 7)

Honuaulu Series

The Honuaulu series consists of well-drained silty clay loams that formed in volcanic ash. These are gently sloping to moderately steep soils on uplands. They are at an elevation ranging from 1,000 to 2,500 feet and receive from 60 to 80 inches of rainfall annually, mostly during the summer months. The mean annual soil temperature is between 65° and 68° F. The natural vegetation consists of Christmas berry, guava, hilograss, and molassesgrass. These soils are in the same general area as Kainaliu and Kealakekua soils.

Honuaulu soils are used mostly for coffee and pasture. Small areas are used for macadamia nuts, bananas, citrus fruits, avocados, and truck crops.

Honuaulu very stony silty clay loam, 6 to 20 percent slopes (HUD).—This soil is low on the leeward side of Mauna Loa and Hualalai. Stones cover 1 to 3 percent of its surface.

A representative profile has a surface layer of very dark brown silty clay loam about 9 inches thick. The subsoil is dark-brown cobbly and stony silty clay loam about

28 inches thick. The substratum is Aa lava. The surface layer is strongly acid. The subsoil is medium acid. This soil dehydrates irreversibly into fine sand-size aggregates. Some areas are very stony or extremely stony.

Representative profile, Kealakekua Quadrangle, lat. 19°32′24″ N. and long. 155°54′50″ W.:

Ap—0 to 9 inches, very dark brown (10YR 2/2) silty clay loam; strong, medium and fine, subangular blocky structure; hard, friable, slightly sticky, and slightly plastic; many roots; many fine pores; 10 percent gravel-size basalt fragments; many stones on surface; strongly acid; abrupt, wavy boundary. (8 to 12 inches thick)

B21—9 to 18 inches, dark-brown (10YR 3/3) silty clay loam; weak, medium and fine, subangular blocky structure; hard, friable, slightly sticky, plastic, and weakly smeary; many roots; many medium and fine pores; 10 to 15 percent gravel-size basalt fragments; strongly acid; clear, wavy boundary. (8 to 15 inches thick)

B22—18 to 27 inches, dark-brown (10YR 3/3) cobbly silty clay loam; weak, medium and fine, subangular blocky structure; hard, friable, slightly sticky, plastic, and weakly smeary; many roots; many medium and fine pores; 15 to 20 percent cobbly basalt fragments; medium acid; clear, wavy boundary. (9 to 15 inches thick)

B23—27 to 37 inches, dark-brown (10YR 3/3) very stony silty clay loam; weak, medium and fine, subangular blocky structure; hard, friable, slightly sticky, plastic, and weakly smeary; common roots; many fine pores; 50 to 60 percent Aa lava of gravel to stone size; medium acid; abrupt, wavy boundary. (10 to 15 inches thick)

IIC—37 inches, fragmental Aa lava.

The depth to fragmental Aa lava ranges from 36 to 40 inches. The A horizon ranges from 7.5YR to 10YR in hue and from strong to moderate in structure. The structure of the B horizon is weak to moderate. Lava fragments from gravel to stone size make up 10 to 60 percent of the soil mass.

Included in mapping are small areas of soils less than 20 inches deep over pahoehoe lava bedrock.

Permeability is rapid, runoff is slow, and the erosion hazard is slight. Roots can penetrate to a depth of 3 feet or more.

This soil is used mainly for pasture and coffee. Small areas are used for macadamia nuts, bananas, citrus fruits, avocados, and truck crops. (Capability subclass VIs, nonirrigated; pasture group 7; woodland group 5)

Honuaulu extremely stony silty clay loam, 12 to 20 percent slopes (HVD).—This soil is similar to Honuaulu very stony silty clay loam, 6 to 20 percent slopes, except that stones cover from 3 to 15 percent of the surface.

This soil is used mostly for coffee and pasture. Small areas are used for macadamia nuts, bananas, citrus fruits, and avocados. (Capability subclass VIIs, nonirrigated; pasture group 7; woodland group 5)

Huikau Series

The Huikau series consists of somewhat excessively drained loamy sands that formed in volcanic ash, pumice, and cinders. These are moderately steep soils on uplands. They are at an elevation ranging from 6,000 to 9,000 feet and receive from 15 to 25 inches of rainfall annually. Snow occasionally covers these soils for a few days during the winter. The mean annual soil temperature is between 47° and 52° F. The natural vegetation consists of hardstem lovegrass, kalamaloa, naio, mamani, and puakeawe. These soils are in the same general area as Apakuie and Kilohana soils.

Huikau soils are used for wildlife habitat.

Huikau loamy sand, 12 to 20 percent slopes (rHID).—This soil occupies the higher elevations of Mauna Kea.

In a representative profile the surface layer is very dark brown loamy sand about 5 inches thick. The next layer is about 12 inches thick and consists of stratified, dark reddish-brown sandy loam and loamy sand. This is underlain by alternating layers of black volcanic ash, cinders, and pumice to a depth of 60 inches or more. This soil is neutral throughout the profile. It is extremely stony in places.

Representative profile, Umikoa Quadrangle, lat. 19°53′55″ N. and long. 155°23′48″ W.:

A1—0 to 5 inches, very dark brown (10YR 2/2) loamy sand; dark grayish brown (2.5YR 4/2) when dry; single grain; loose; many roots; many, fine, interstitial pores; neutral; abrupt, smooth boundary. (5 to 8 inches thick)

C1—5 to 12 inches, dark reddish-brown (5YR 3/4) sandy loam; single grain; loose; common roots; many, fine and very fine, interstitial pores; neutral; abrupt, smooth boundary. (3 to 7 inches thick)

C2—12 to 17 inches, dark reddish-brown (5YR 2/3) loamy sand; single grain; loose; common roots; many, fine, interstitial pores; many fine cinders; neutral; abrupt, smooth boundary. (4 to 5 inches thick)

C3—17 to 60 inches, black (N 2/0) sand and cinders; single grain; loose; few roots; 30 to 60 percent Aa lava stones below a depth of 30 inches; neutral.

The structure of the A1 horizon ranges from weak, granular to single grain. In many areas without vegetation, the A horizon has been removed by erosion.

Included in mapping are small areas of very stony land.

Permeability is very rapid, and the runoff is slow. The hazard of soil blowing is severe. Roots can penetrate to a depth of 60 inches or more.

This soil is used for wildlife habitat. (Capability subclass VIe, nonirrigated; pasture group 14; woodland group 16)

Huikau loamy sand, 12 to 20 percent slopes, eroded (rHID2).—This soil is protected by only a sparse cover. The surface layer has been removed by erosion, and the remaining soil material consists of stratified sand and cinders. Soil blowing is active, and dunes are common in some areas.

This soil is used for wildlife habitat. (Capability subclass VIIe, nonirrigated; pasture group 14; woodland group 16)

Huikau extremely stony loamy sand, 12 to 20 percent slopes (rHLD).—This soil is similar to Huikau loamy sand, 12 to 20 percent slopes, except that stones cover 3 to 15 percent of the surface. The depth to fragmental Aa lava is 30 to 40 inches.

This soil is used for wildlife habitat. (Capability subclass VIIs, nonirrigated; pasture group 14; woodland group 16)

Hydrandept-Tropofolist Association

The Hydrandept-Tropofolist association (rHP) consists of soils on the windward side of Mauna Loa in the Kau Forest Reserve. These soils are members of the Hydrandept and Tropofolist great soil groups.

Hydrandepts make up 50 to 70 percent of the area. These soils dehydrate irreversibly into aggregates of fine gravel size. They are smeary and are more than 20 inches deep. They are similar to soils of the Akaka and Piihonua series. Tropofolists make up 30 to 50 percent of the area. They are thin, organic soils on lava flows. They have only 4 to 12 inches of organic material over fragmental Aa or pahoehoe lava. These soils are similar to those of the Kahaluu, Keei, Kiloa, and Lalaau series.

The elevation ranges from 2,000 to 6,000 feet, and the annual rainfall is 80 to 200 inches. At lower elevations the vegetation is a dense stand of ohia and tree fern. At higher elevations koa and ohia are dominant. The slope is dominantly 6 to 20 percent.

Mapped with this association are small, swampy areas where the vegetation is sparse and stunted.

This association is used as woodland, wildlife habitat, and watershed. (Hydrandepts: dominantly capability subclass IVe, nonirrigated; woodland group 6. Tropofolists: dominantly capability subclass VIIs, nonirrigated. Pasture and woodland groups vary with rainfall, elevation, and nature of underlying rock)

Kaalualu Series

The Kaalualu series consists of well-drained loamy sands that formed in volcanic ash. These are gently sloping to moderately sloping soils in coastal areas at an elevation ranging from near sea level to 1,000 feet. They receive from 20 to 40 inches of rainfall annually, and their mean annual soil temperature is between 73° and 75° F. The natural vegetation consists of lantana, bermudagrass, indigo, and Japanese tea. These soils are in the same general area as Kaimu, Kamaoa, Pakini, and Punaluu soils.

Kaalualu soils are used for pasture.

Kaalualu extremely stony loamy sand, 2 to 12 percent slopes (KBC).—This soil is in low coastal areas on Mauna Loa at South Point.

In a representative profile the surface layer is dark-brown cobbly loamy sand and loam about 5 inches thick. The subsoil is dark-brown cobbly silt loam about 19 inches thick. The substratum is fragmental Aa lava. This soil is neutral throughout the profile.

Representative profile, Ka Lae Quadrangle, lat. 18°-57′25″ N. and long. 155°40′09″ W.:

A11—0 to 2 inches, dark-brown (7.5YR 3/2) loamy sand; dark yellowish brown (10YR 4/4) when dry; single grain; loose; many roots; many fine pores; cobble-size Aa lava fragments make up 10 to 20 percent of volume; sand fraction is 20 to 30 percent olivine sand; neutral; abrupt, smooth boundary. (1 to 2 inches thick)

A12—2 to 5 inches, dark-brown (7.5YR 3/3) cobbly loam; dark yellowish brown (10YR 4/4) when dry; weak, medium and fine, granular structure; soft, friable, nonsticky, and nonplastic; many roots; many fine pores; cobble-size Aa lava fragments make up 30 percent of volume; neutral; clear, smooth boundary. (2 to 6 inches thick)

B2—5 to 24 inches, dark-brown (7.5YR 3/3) cobbly silt loam; dark yellowish brown (10YR 3/4) when dry; weak, coarse, prismatic structure; soft, friable, nonsticky, and nonplastic; many roots; many fine pores; Aa lava fragments make up 40 to 50 percent of volume; slight effervescence with dilute hydrochloric acid in places; neutral; clear, wavy boundary. (12 to 30 inches thick)

IIC—24 inches, fragmental Aa lava with patchy coatings of calcium carbonate.

The depth to Aa lava ranges from 20 to 30 inches. The texture of the A11 horizon ranges from loamy sand to very fine sandy loam. The hue of the solum ranges from 7.5YR to 10YR.

Included in mapping are small areas of Kamaoa and Pakini soils.

Permeability is rapid, runoff is slow, and the erosion hazard is slight. Roots can penetrate to a depth of 20 to 30 inches.

This soil is used for pasture. (Capability subclass VIIs, nonirrigated; pasture group 2)

Kahaluu Series

The Kahaluu series consists of well-drained, thin, organic soils overlying pahoehoe lava bedrock. These soils are moderately sloping to moderately steep. They are on uplands at an elevation ranging from 3,500 to 7,000 feet and receive from 90 to 150 inches of rainfall annually. Their mean annual soil temperature is between 55° and 57° F. The natural vegetation consists of ohia, tree fern, amaumau fern, uluhe fern, and puakeawe. These soils occur with Kealakekua, Keei, Kiloa, Kona, and Lalaau soils.

Kahaluu soils are used for woodland and pasture.

Kahaluu extremely rocky muck, 6 to 20 percent slopes (rKAD).—This soil is at intermediate elevations on Mauna Kea and Mauna Loa. Rock outcrop occupies 30 to 50 percent of the surface area.

In a representative profile the surface layer is very dark brown muck about 5 inches thick. It is underlain by pahoehoe lava bedrock. This soil is very strongly acid.

Representative profile, Upper Piihonua Quadrangle, lat. 19°41′20″ N. and long. 155°16′04″ W.:

O2—5 inches to 0, very dark brown (10YR 2/2) muck; weak, very fine, subangular blocky structure; friable, slightly sticky, slightly plastic, and strongly smeary; many roots; many fine pores; very strongly acid; abrupt, wavy boundary. (3 to 10 inches thick)

IIR—0 to 10 inches, pahoehoe lava bedrock.

Included in mapping are small areas of Rock land.

The soil above the bedrock is rapidly permeable. The bedrock is very slowly permeable, although water moves rapidly through the cracks. Runoff is rapid. Roots extend only to the bedrock or to a depth of a few feet where the bedrock is fractured. There is little or no erosion hazard.

This soil is too shallow and rocky for cultivation. Most of it is in native woodland. A few areas are cleared and used for pasture. (Capability subclass VIIs, nonirrigated; pasture group 10)

Kahua Series

The Kahua series consists of somewhat poorly drained silty clay loams that formed in volcanic ash. These soils are gently sloping to moderately steep. They are on uplands at an elevation ranging from 3,500 to 4,000 feet and receive from 60 to 100 inches of rainfall annually. The mean annual soil temperature is 58° F. The

natural vegetation consists of ohia, tree fern, sedges, kikuyugrass, and hilograss. These soils and Amalu, Kehena, and Maile soils are in the same general area.

Kahua soils are used for pasture.

Kahua silty clay loam, 6 to 20 percent slopes (KCD).—This is an undulating to rolling soil on the Kohala Mountains.

A representative profile has a surface layer of very dark brown silt loam about 2 inches thick. This layer is separated from the subsoil by about 6 inches of grayish-brown silty clay. The upper part of the subsoil is dark-brown to very dark grayish-brown silty clay loam about 28 inches thick. The lower part consists of dark-brown, very dark gray, and reddish-brown silty clay loam and coarse cinders. A thin ironstone seam occurs at a depth of 8 to 40 inches. The profile is strongly acid to extremely acid. This soil dehydrates irreversibly into fine gravel-size aggregates.

Representative profile, Hawi Quadrangle, lat. 20°07′43″ N. and long. 155°46′03″ W.:

A1—0 to 2 inches, very dark brown (7.5YR 2/2) silt loam; weak, fine, granular structure; friable, slightly sticky, plastic, and weakly smeary; matted roots; many very fine pores; extremely acid; abrupt, smooth boundary. (2 to 4 inches thick)

A2—2 to 8 inches, grayish-brown (10YR 5/2) silty clay; many, fine, faint mottles of dark yellowish brown (10YR 3/4); moderate, very fine, subangular blocky structure; friable, sticky, plastic, and weakly smeary; many roots; common fine pores; very strongly acid; abrupt, wavy boundary. (3 to 7 inches thick)

B21ir—8 to 15 inches, very dark grayish-brown (10YR 3/2) silty clay loam; few, fine, faint mottles of dark yellowish brown (10YR 3/4); moderate, medium and fine, subangular blocky structure; friable, slightly sticky, plastic, and strongly smeary; many roots; many fine pores; patchy, gelatinlike coatings on peds; ironstone seam ⅛ inch thick; roots matted over ironstone seam; very strongly acid; abrupt, smooth boundary. (6 to 9 inches thick)

B22—15 to 23 inches, dark-brown (10YR 4/3) silty clay loam; moderate, medium and fine, subangular blocky structure; friable, sticky, plastic, and strongly smeary; common roots; many very fine pores; thick, gelatinlike coatings on peds; a few scattered cinder and rock fragments; very strongly acid; clear, smooth boundary. (7 to 10 inches thick)

B23—23 to 36 inches, dark grayish-brown (10YR 4/2) silty clay loam; moderate, fine, subangular blocky structure; friable, sticky, plastic, and strongly smeary; common roots; many very fine pores; root channels coated with dark-brown (7.5YR 3/2) material; thick, gelatinlike coatings on peds; a few scattered patches of dark gray (10YR 4/1); strongly acid; abrupt, wavy boundary. (11 to 14 inches thick)

B24—36 to 60 inches, dark yellowish-brown (10YR 4/4), dark-brown (7.5YR 4/2), very dark gray (N 3/0), and reddish-brown (5YR 4/4) variegated horizon of silty clay loam and coarse cinders; massive; friable, sticky, plastic, and strongly smeary; few roots; many very fine pores; thick, gelatinlike coatings on peds; very strongly acid.

The depth to bedrock is 40 inches to more than 60 inches. The depth to the ironstone seam is 8 to 40 inches. The A horizon ranges from 5YR to 10YR in hue.

Permeability is moderately slow, runoff is slow, and the erosion hazard is slight. Roots can penetrate to bedrock.

This soil is used for pasture and for wildlife habitat. (Capability subclass VIw, nonirrigated; pasture group 8; woodland group 6)

Kaimu Series

The Kaimu series consists of well-drained, thin organic soils over Aa lava. These are gently sloping to moderately steep soils on uplands at an elevation ranging from near sea level to 1,000 feet. They receive from 40 to 60 inches of rainfall annually, and their mean annual soil temperature is between 72° and 74° F. The natural vegetation consists of Christmas berry, guava, guineagrass, and lantana. These soils and Kaalualu, Kainaliu, Naalehu, Pakini, Punaluu, and Waiaha soils are in the same general area.

Kaimu soils are used for pasture, macadamia nuts, papaya, and citrus fruits.

Kaimu extremely stony peat, 6 to 20 percent slopes (rKED).—This soil is at low elevations on Mauna Loa.

In a representative profile the surface layer is very dark brown extremely stony peat about 3 inches thick. It is underlain by fragmental Aa lava. This soil is neutral in reaction.

Representative profile, Naalehu Quadrangle, lat. 19°06′42″ N. and long. 155°32′40″ W.:

O2—3 inches to 0, very dark brown (10YR 2/2) extremely stony peat; weak, very fine, granular structure; very friable, nonsticky, and nonplastic; many roots; many fine pores; Aa lava fragments from gravel to stone size make up 50 to 80 percent of the volume; neutral; clear, smooth boundary.

IIC—0 to 20 inches, fragmental Aa lava; very little soil material in voids and cracks.

The O2 horizon ranges from 2 to 8 inches in thickness and from 5YR to 10YR in hue.

Included in mapping are small areas of Very stony land.

Permeability is rapid, runoff is slow, and the erosion hazard is slight.

This soil is not suitable for cultivation. Most of it is in native woodland. Small areas are used for pasture, macadamia nuts, papaya, and citrus fruits. (Capability subclass VIIs, nonirrigated; pasture group 5)

Kainaliu Series

The Kainaliu series consists of well-drained silty clay loams that formed in volcanic ash. These are moderately sloping to moderately steep soils on uplands at an elevation ranging from 800 to 1,200 feet. The annual rainfall is 40 to 60 inches, and most of it falls during the summer months. The mean annual soil temperature is between 71° and 73° F. The natural vegetation consists of guava, lantana, koa haole, and guineagrass. These soils and Honuaulu, Kaimu, Punaluu, and Waiaha soils are in the same general area.

Kainaliu soils are used mostly for pasture, coffee, and macadamia nuts. A small acreage is used for truck crops.

Kainaliu extremely stony silty clay loam, 12 to 20 percent slopes (KEC).—This soil is at low elevations on Mauna Loa and Hualalai.

In a representative profile the surface layer is very dark brown extremely stony silty clay loam about 10 inches thick. The subsoil consists of dark-brown very stony silty clay loam and silt loam. It is about 16 inches thick and is underlain by fragmental Aa lava.

The surface layer is medium acid, and the subsoil is neutral.

Representative profile, Kealakekua Quadrangle, lat. 19°32′23″ N. and long. 155°56′15″ W.:

Ap—0 to 10 inches, very dark brown (10YR 2/2) extremely stony silty clay loam; strong, medium and fine, subangular blocky structure; hard, friable, slightly sticky, and plastic; many roots; many very fine pores; 10 to 15 percent Aa lava fragments from gravel to stone size; medium acid; abrupt, smooth boundary. (6 to 12 inches thick)

B21—10 to 18 inches, dark-brown (7.5YR 3/2) stony silty clay loam; weak, medium and fine, subangular blocky structure; slightly hard, friable, slightly sticky, and plastic; many roots; many medium and fine pores; 20 to 40 percent Aa lava fragments from gravel to stone size; neutral; clear, smooth boundary. (8 to 10 inches thick)

B22—18 to 26 inches, dark-brown (7.5YR 3/3) very stony silt loam; weak, medium and fine, subangular blocky structure; slightly hard, friable, slightly sticky, and slightly plastic; few roots; many medium and fine pores; 50 to 60 percent Aa lava fragments from gravel to stone size; neutral; gradual, wavy boundary. (6 to 10 inches thick)

IIR—26 inches, fragmental Aa lava.

The depth to fragmental Aa lava ranges from 20 to 40 inches. The hue of the solum ranges from 5YR to 10YR. The structure of the A horizon is moderate to strong, and that of the B horizon is weak to moderate.

Included in mapping are small areas of soils underlain by pahoehoe lava at a depth of less than 30 inches. Also included are soils at lower elevations that are similar to the Waiaha soils, except that they are underlain by fragmental Aa lava.

Permeability is rapid, runoff is slow, and the erosion hazard is slight. Roots penetrate to a depth of 26 inches or more.

This soil is used for coffee, macadamia nuts, and pasture. (Capability subclass VIIs, nonirrigated; pasture group 5; woodland group 2)

Kainaliu very stony silty clay loam, 12 to 20 percent slopes (KDD).—This soil is similar to Kainaliu extremely stony silty clay loam, 12 to 20 percent slopes, except that it is less stony. Most areas of this soil follow the pattern of the lava flows and are long and narrow, but some are isolated and are surrounded by recent lava flows.

Most of the acreage is used for coffee, macadamia nuts, and pasture. A small acreage is used for truck crops. (Capability subclass VIs, nonirrigated; pasture group 5; woodland group 2)

Kaiwiki Series

The Kaiwiki series consists of well-drained silty clay loams. These soils formed in a series of layers of volcanic ash and have a banded appearance. They are gently sloping to steep soils on uplands at an elevation ranging from 800 to 1,500 feet. They receive from 150 to 200 inches of rainfall annually and have a mean annual soil temperature of 70° F. The natural vegetation consists of hilograss, ohia, tree fern, californiagrass, and wainakugrass. These soils and Akaka, Hilo, and Honokaa soils are in the same general area.

Kaiwiki soils are used for sugarcane.

Kaiwiki silty clay loam, 0 to 10 percent slopes (KaC).—This soil is low on the windward side of Mauna Kea. The slopes are long and are dissected by many narrow, deep gulches.

In a representative profile the surface layer is dark-brown silty clay loam about 15 inches thick. The subsoil is dark-brown and dark reddish-brown silty clay loam about 48 inches thick. The surface layer is very strongly acid and medium acid. The subsoil is medium acid to strongly acid. This soil dehydrates irreversibly into fine gravel-size aggregates.

Representative profile, Honomu Quadrangle, lat. 19°45′30″ N. and long. 155°08′10″ W.:

Ap1—0 to 11 inches, dark-brown (7.5YR 3/3) silty clay loam; strong, very fine and fine, subangular blocky structure; hard, friable, slightly sticky, and plastic; many very fine and fine pores; many roots; very strongly acid; abrupt, wavy boundary. (9 to 12 inches thick)

Ap2—11 to 15 inches, dark-brown (7.5YR 3/2) silty clay loam; moderate, medium and fine, subangular blocky structure; very hard, friable, slightly sticky, plastic, and moderately smeary; many fine pores; many roots; many sugarlike coatings; medium acid; abrupt, smooth boundary. (4 to 6 inches thick)

B1—15 to 17 inches, dark reddish-brown (5YR 3/4) sandy clay loam; massive; firm, slightly sticky, slightly plastic, and strongly smeary; common roots; extremely porous layer of volcanic ash; medium acid; abrupt, smooth boundary. (2 to 3 inches thick)

B21—17 to 21 inches, dark-brown (10YR 3/3) silty clay loam; moderate, fine and medium, subangular blocky structure; very hard, friable, sticky, plastic, and strongly smeary; common roots; many very fine pores; medium acid; abrupt, smooth boundary. (3 to 4 inches thick)

B22—21 to 27 inches, dark-brown (7.5YR 3/4) silty clay loam; weak, medium, prismatic structure that breaks to moderate, medium and fine, subangular blocky structure; extremely hard, friable, sticky, plastic, and strongly smeary; common roots; many very fine pores; strongly acid; abrupt, smooth boundary. (1 to 6 inches thick)

B23—27 to 29 inches, dark reddish-brown (5YR 3/4) silty clay loam; weak, fine, subangular blocky structure; extremely hard, friable, slightly sticky, plastic, and strongly smeary; common roots; very porous; common, hard, fine gravel-size nodules of volcanic ash; medium acid; abrupt, smooth boundary. (1 to 2 inches thick)

B24—29 to 32 inches, dark-brown (10YR 3/3) silty clay loam; moderate, medium and fine, subangular blocky structure; extremely hard, friable, sticky, plastic, and strongly smeary; few roots; many fine pores; medium acid; abrupt, smooth boundary. (1 to 3 inches thick)

B25—32 to 60 inches, dark-brown (7.5YR 3/3) and dark reddish-brown (5YR 3/4) silty clay loam; moderate, medium and fine, subangular blocky structure; extremely hard, friable, sticky, plastic, and strongly smeary; few roots; many fine and very fine pores; strongly acid.

The depth to bedrock is more than 6 feet. The hue of the solum ranges from 5YR to 10YR.

Included in mapping are small areas of stony and moderately shallow soils.

Permeability is rapid, runoff is slow, and the erosion hazard is slight. Roots can penetrate to a depth of 5 feet or more.

This soil is used for sugarcane. (Capability subclass IIIe, nonirrigated; sugarcane group 4; pasture group 9; woodland group 7)

Kaiwiki silty clay loam, 10 to 20 percent slopes (KaD).—This soil is similar to Kaiwiki silty clay loam, 0 to

10 percent slopes, except that it is moderately sloping. It is used mostly for sugarcane. Small areas are used for pasture and truck crops. (Capability subclass IVe, nonirrigated; sugarcane group 4; pasture group 9; woodland group 7)

Kaiwiki silty clay loam, 20 to 35 percent slopes (KaE).—This soil is on the sides of drainageways. It is similar to Kaiwiki silty clay loam, 0 to 10 percent slopes, except for the steep slopes. Runoff is medium, and the erosion hazard is moderate.

This soil is used mostly for sugarcane. A small acreage is used for pasture and woodland. (Capability VIe, nonirrigated; sugarcane group 4; pasture group 9; woodland group 7)

Kamakoa Series

The Kamakoa series consists of somewhat excessively drained very fine sandy loams that formed in recent alluvium. These soils are nearly level to gently sloping. They are on the flood plains of Mauna Kea at an elevation ranging from 1,000 to 4,000 feet. They receive from 20 to 40 inches of rainfall annually, and their mean annual soil temperature is between 62° and 65° F. The natural vegetation consists of bermudagrass, aalii, cactus, and mountain dandelion. These soils and Puu Pa and Waikaloa soils are in the same general area.

Kamakoa soils are used for pasture.

Kamakoa very fine sandy loam, 0 to 10 percent slopes (KGC)—This soil occurs as long, narrow areas along shallow, intermittent streams. The slope is dominantly 3 percent.

In a representative profile the surface layer is about 9 inches thick and consists of dark-brown very fine sandy loam and very fine sand. It is underlain by alternate layers of fine, medium, and coarse sand and gravel. At a depth below 30 inches, the layers commonly contain calcium carbonate. Basalt occurs at a depth of 4 to 6 feet. The surface layer is mildly alkaline, and the subsoil is mildly alkaline to very strongly alkaline.

Representative profile, Nohonaohae Quadrangle, lat. 19°57′29″ N. and long. 155°40′47″ W.:

A11—0 to 4 inches, dark-brown (7.5YR 3/3) very fine sandy loam; dark grayish brown (10YR 4/2) when dry; weak, very fine, granular structure; soft, friable, nonsticky, and nonplastic; many roots; many fine pores; few pebbles; mildly alkaline; clear, smooth boundary. (3 to 6 inches thick)

A12—4 to 9 inches, dark-brown (7.5YR 3/3) very fine sand; dark grayish brown (10YR 4/2) when dry; weak, medium and fine, subangular blocky structure; soft, friable, nonsticky, and nonplastic; many roots; many very fine and fine pores; few pebbles; mildly alkaline; abrupt, smooth boundary. (4 to 6 inches thick)

B2—9 to 22 inches, very dark brown (7.5YR 2/2) coarse, medium, and fine sand; dark brown (7.5YR 4/3) when dry; single grain; loose; many roots; many fine pores; many pebbles and stones; calcium carbonate deposit on pebbles and stones effervesces with dilute hydrochloric acid; mildly alkaline; abrupt, smooth boundary. (11 to 13 inches thick)

C1—22 to 29 inches, very dark grayish-brown (10YR 3/2) very fine sand; brown (10YR 5/3) when dry; single grain; loose; common roots; many very fine pores; mildly alkaline; abrupt, smooth boundary. (7 to 8 inches thick)

C2—29 to 34 inches, gray (N 3/0) coarse sand; single grain; loose; few roots; many medium pores; a thin, broken layer of grayish sand is in the upper inch of this layer; mildly alkaline; abrupt, smooth boundary. (4 to 6 inches thick)

IIC3ca—34 to 44 inches, dark-brown (7.5YR 3/3) very fine sandy loam; yellowish brown (10YR 5/4) when dry; weak, medium and coarse, subangular blocky structure; slightly hard, friable, nonsticky, and nonplastic; few roots; many very fine pores; strong effervescence with dilute hydrochloric acid; strongly alkaline; abrupt, wavy boundary. (5 to 12 inches thick)

IIC4ca—44 to 48 inches, dark-brown (7.5YR 3/3) very fine sandy loam; brown (7.5YR 5/2) when dry; many, white, myceliumlike mottles of calcium carbonate; weak, coarse and medium, subangular blocky structure; slightly hard, friable, nonsticky, and nonplastic; few roots; many very fine pores; strong effervescence with dilute hydrochloric acid; very strongly alkaline.

The texture of the A horizon ranges from silt loam to very fine sandy loam or very fine sand. The structure ranges from platy to weak granular or subangular blocky. The horizon containing calcium carbonate is lacking in some areas.

Included in mapping are small areas of very stony soils and small areas that are 20 to 50 inches deep over gravel and hard, consolidated sand.

Permeability is rapid, runoff is slow, and the erosion hazard is slight. Roots can penetrate to a depth of 4 feet or more. This soil is high in fertility and is well supplied with bases. It is used for pasture. (Capability subclass IIIe, nonirrigated; pasture group 4; woodland group 1)

Kamaoa Series

The Kamaoa series consists of well-drained loams that formed in volcanic ash. These are gently sloping to moderately sloping soils on uplands. They are at an elevation ranging from 1,000 to 2,200 feet and receive from 40 to 60 inches of rainfall annually. Their mean annual soil temperature is between 66° and 69° F. The natural vegetation consists of Christmas berry, guava, rhodesgrass, and bermudagrass. These soils and Kaalualu, Naalehu, and Pakini soils are in the same general area.

Kamaoa soils are used for pasture.

Kamaoa loam, 6 to 12 percent slopes (KIC).—This soil is on the south side of Mauna Loa near South Point.

In a representative profile the surface layer is dark-brown loam about 7 inches thick. The subsoil is about 60 inches thick and consists of dark reddish-brown and dark-brown loam, silty clay loam, and silt loam. The surface layer is medium acid, and the subsoil is neutral. The surface is extremely stony in places.

Representative profile, Kahuku Ranch Quadrangle, lat. 19°02′31″ N. and long. 155°42′05″ W.:

A1—0 to 7 inches, dark-brown (7.5YR 3/2) loam; brown (10YR 5/3) when dry; strong, medium and fine, subangular blocky structure; hard, friable, slightly sticky, and plastic; many roots; many fine pores; medium acid; abrupt, wavy boundary. (6 to 9 inches thick)

B1—7 to 21 inches, dark reddish-brown (5YR 3/4) loam; strong brown (7.5YR 5/6) when dry; weak, fine, subangular blocky structure; soft, very friable, slightly sticky, and slightly plastic; many roots;

many fine pores; neutral; clear, wavy boundary. (8 to 17 inches thick)

B21—21 to 47 inches, dark-brown (7.5YR 3/3) silty clay loam; strong brown (7.5YR 5/8) when dry; weak, fine, subangular blocky structure; hard, very friable, slightly sticky, and plastic; many roots; many very fine pores; neutral; abrupt, smooth boundary. (19 to 27 inches thick)

B22—47 to 68 inches, dark-brown (7.5YR 3/3) silt loam; yellowish brown (10YR 5/8) when dry; weak, fine, subangular blocky structure; soft, very friable, slightly sticky, and plastic; many roots; many fine and very fine pores; neutral.

The depth to underlying basalt ranges from 40 inches to more than 60 inches. The A horizon has moderate to strong structure. When moist, the A horizon has a hue of 7.5YR to 10YR and a value and chroma of 2 and 3. The hue of the B horizon ranges from 5YR to 10YR.

Included in mapping are small areas of shallow soils over pahoehoe lava.

Permeability is moderately rapid, runoff is slow, and the erosion hazard is slight. Roots can penetrate to a depth of 2 feet or more.

This soil is used for pasture. (Capability subclass IIIe, nonirrigated; pasture group 4; woodland group 1)

Kamaoa extremely stony loam, 6 to 12 percent slopes (KKC).—This soil is similar to Kamaoa loam, 6 to 12 percent slopes, except that stones occupy 3 to 15 percent of the surface. Roots can penetrate to a depth of 3 feet or more.

This soil is used for pasture. (Capability subclass VIIs, nonirrigated; pasture group 4; woodland group 1)

Kamaoa loam, moderately shallow, 6 to 12 percent slopes (KJC).—This soil is similar to Kamaoa loam, 6 to 12 percent slopes, except that the depth to bedrock ranges from 20 to 30 inches. Roots can penetrate to bedrock. Included in mapping are small areas of soils less than 20 inches deep over bedrock.

This soil is used for pasture. (Capability subclass IIIs, nonirrigated; pasture group 4; woodland group 1)

Kapapala Series

The Kapapala series consists of well-drained loams that formed in recent volcanic ash. These soils are nearly level to moderately steep. They are on uplands at an elevation ranging from 2,000 to 5,500 feet and receive from 40 to 60 inches of rainfall annually. Their mean annual soil temperature is between 59° and 61° F. The natural vegetation consists of rattail, natal redtop, bermudagrass, guava, and bracken fern. These soils and Hanipoe and Naalehu soils are in the same general area.

Kapapala soils are used for pasture.

Kapapala loam, 10 to 20 percent slopes (KLD).—This rolling soil is on the leeward side of Mauna Loa.

In a representative profile the surface layer is dark reddish-brown loam about 4 inches thick. Below the surface layer are banded layers of very dark grayish-brown and dark-brown soil ranging from loam to fine sand (fig. 6). Pahoehoe lava is at a depth of about 48 inches. The surface layer is slightly acid, and the subsoil is mildly alkaline to neutral.

Representative profile, Wood Valley Quadrangle, lat. 19°22′00″ N. and long. 155°23′02″ W.:

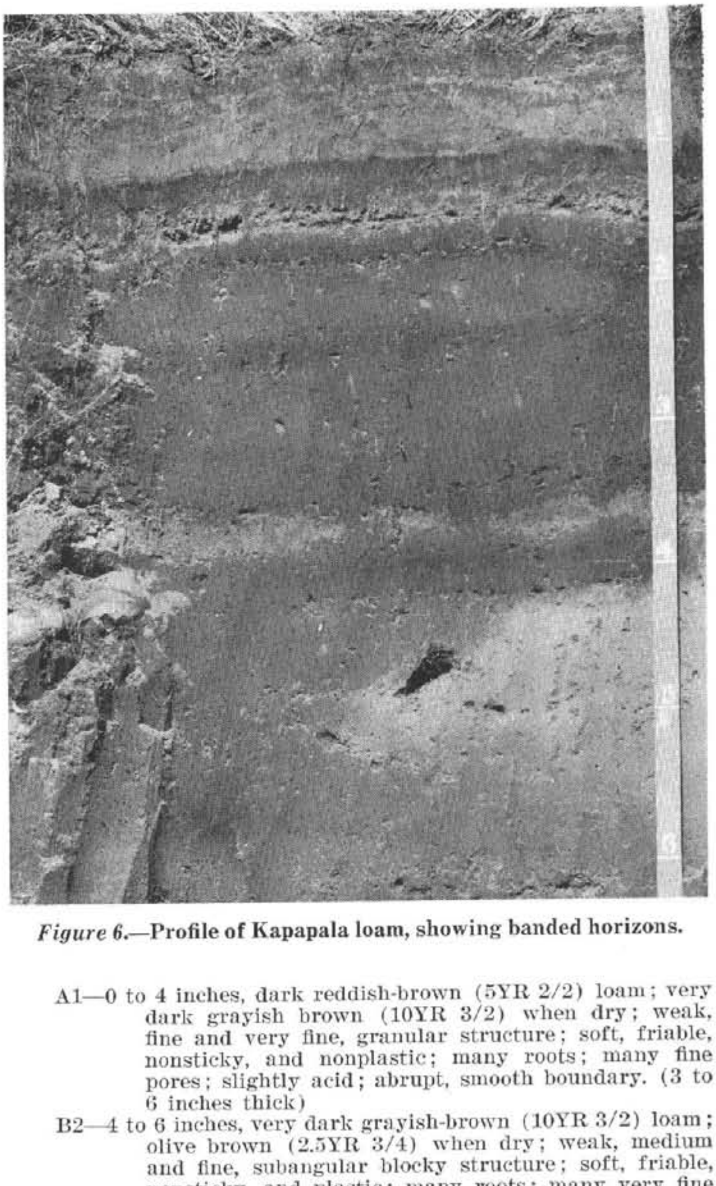


Figure 6.—**Profile of Kapapala loam, showing banded horizons.**

A1—0 to 4 inches, dark reddish-brown (5YR 2/2) loam; very dark grayish brown (10YR 3/2) when dry; weak, fine and very fine, granular structure; soft, friable, nonsticky, and nonplastic; many roots; many fine pores; slightly acid; abrupt, smooth boundary. (3 to 6 inches thick)

B2—4 to 6 inches, very dark grayish-brown (10YR 3/2) loam; olive brown (2.5YR 3/4) when dry; weak, medium and fine, subangular blocky structure; soft, friable, nonsticky, and plastic; many roots; many very fine pores; a half-inch, discontinuous, very dark brown (7.5YR 2/2) layer is at the top of this horizon; neutral; abrupt, smooth boundary. (1 to 3 inches thick)

IIC1—6 to 15 inches, dark grayish-brown (10YR 4/2), dark-brown (10YR 3/3), black (10YR 2/1) fine sand and very fine sand; gray (10YR 6/1) and very dark gray (N 3/0) when dry; single grain; loose; many roots; many fine pores; mildly alkaline; abrupt, smooth boundary. (8 to 10 inches thick)

IIIC2—15 to 23 inches, very dark brown (7.5YR 2/2) loamy sand; brown (7.5YR 5/4) when dry; massive; soft, very friable, nonsticky, and nonplastic; many roots; many fine pores; mildly alkaline; abrupt, smooth boundary. (8 to 10 inches thick)

IVC3—23 to 26 inches, very dark grayish-brown (10YR 3/2) loam; yellowish brown (10YR 5/4) when dry; massive; soft, very friable, nonsticky, and nonplastic; many roots; many very fine pores; neutral; clear, wavy boundary. (1 to 4 inches thick)

IVC4—26 to 40 inches, dark-brown (7.5YR 3/3) silt loam; dark yellowish brown (10YR 4/6) when dry; weak, coarse, prismatic structure; soft, very friable, nonsticky, and nonplastic; many roots; many very fine

and fine pores; a few pieces of pumice; neutral; clear, wavy boundary. (10 to 16 inches thick)

IVC5—40 to 48 inches, dark-brown (7.5YR 3/4) loam; light yellowish brown (10YR 6/4) when dry; weak, medium and coarse, subangular blocky structure; soft, friable, nonsticky, and nonplastic; common roots; many fine and very fine pores; neutral; abrupt, wavy boundary. (7 to 12 inches thick)

VR—48 inches, pahoehoe lava.

The depth to unconforming bedrock is more than 40 inches. The A horizon ranges from very fine sandy loam to loam in texture, from 5YR to 10YR in hue, and from weak to moderate in structure.

Included in mapping are a few stony and rocky areas on ridges.

Permeability is moderately rapid, runoff is medium, and the erosion hazard is moderate. Roots can penetrate to bedrock.

This soil is used for pasture. (Capability subclass IVe, nonirrigated; pasture group 13; woodland group 10)

Kapapala loam, 0 to 10 percent slopes (KLC).—This soil is similar to Kapapala loam, 10 to 20 percent slopes, except it is gently to moderately sloping and is only 20 to 36 inches deep over bedrock. Runoff is slow, and the erosion hazard is slight. Included in mapping are small areas that have a surface layer of very fine sandy loam. These coarser textured soils are near Wood Valley.

This soil is used for pasture. (Capability subclass IIIe, nonirrigated; pasture group 13; woodland group 10)

Kapapala very rocky loam, 6 to 20 percent slopes (KMD).—Rock outcrops and stones occupy 10 to 25 percent of the surface of this soil. In areas between outcrops the depth to bedrock is 20 to 30 inches.

This soil is used for pasture. (Capability subclass VIs, nonirrigated; pasture group 13; woodland group 10)

Kawaihae Series

The Kawaihae series consists of somewhat excessively drained extremely stony soils that formed in volcanic ash. These soils have a very thin surface layer of fine sandy loam over silt loam and loam. They are gently sloping to moderately sloping soils on coastal plains at an elevation ranging from near sea level to 1,500 feet. The annual rainfall is 5 to 20 inches, most of which falls during the winter months. The mean annual soil temperature is between 74° and 77° F. The natural vegetation consists of kiawe, piligrass, ilima, and fingergrass. These soils and Mahukona, Puu Pa, and Waikaloa soils are in the same general area.

Kawaihae soils are used mainly for pasture, recreation areas, wildlife habitat, and homesites. Small acreages are used for truck crops.

Kawaihae extremely stony very fine sandy loam, 6 to 12 percent slopes (KNC).—This soil is on the leeward coastal plains of Mauna Kea.

In a representative profile the surface layer is dark reddish-brown extremely stony very fine sandy loam about 2 inches thick. Below this is dark reddish-brown and dusky-red stony silt loam and loam. Hard pahoehoe lava bedrock is at a depth of about 33 inches. The surface layer is neutral, and the subsoil is neutral to mildly alkaline.

Representative profile, Kawaihae Quadrangle, lat. 20°03′22″ N. and long. 155°50′02″ W.:

A1—0 to 2 inches, dark reddish-brown (2.5YR 2/4) extremely stony very fine sandy loam; (2.5YR 3/4) when dry; weak, very fine, granular structure; soft, very friable, nonsticky, and slightly plastic; many roots; many very fine pores; stones cover about 50 percent of the surface; neutral; abrupt, smooth boundary. (2 to 4 inches thick)

B2—2 to 16 inches, dark reddish-brown (2.5YR 3/4) stony silt loam; (2.5YR 3/4) when dry; weak, coarse, prismatic structure; soft, very friable, slightly sticky, and slightly plastic; many roots; many very fine pores; stones and cobbles make up about 10 percent of horizon; neutral; clear, smooth boundary. (12 to 18 inches thick)

C1—16 to 24 inches, dark reddish-brown (2.5YR 3/4) stony loam; (2.5YR 3/4) when dry; weak, medium and coarse, prismatic structure; hard, very friable, nonsticky, and slightly plastic; many roots; common very fine pores; common, gray, patchy coatings on ped surfaces; stones make up about 10 percent of horizon; neutral; gradual, wavy boundary. (8 to 10 inches thick)

C2—24 to 33 inches, dusky-red (10R 3/4) stony loam; reddish brown (2.5YR 4/4) when dry; weak, medium and coarse, prismatic structure; hard, friable, slightly sticky, and slightly plastic; few roots; common fine pores; many, gray, patchy coatings on ped surfaces; stones make up about 30 percent of horizon; mildly alkaline; abrupt, wavy boundary. (8 to 10 inches thick)

IIR—33 inches, pahoehoe lava.

The depth to pahoehoe bedrock ranges from 20 to 40 inches. The surface layer ranges from platy to weak, granular in structure and from 2.5YR to 7.5YR in hue. The B horizon ranges from silt loam to loam in texture. In some places calcium carbonate has accumulated in the lower part of the profile or is coated on rocks.

Included in mapping are areas that are underlain by fragmental Aa lava. These inclusions comprise 10 to 20 percent of this mapping unit.

Permeability is moderate, runoff is medium, and the erosion hazard is moderate. Roots can penetrate to bedrock.

This soil is used mostly for pasture, wildlife habitat, and recreation areas. Small areas, less than an acre in size, have been cleared of stones and are used for irrigated truck crops. (Capability subclass VIIs, nonirrigated; pasture group 1)

Kawaihae very rocky very fine sandy loam, 6 to 12 percent slopes (KOC).—This soil is similar to Kawaihae extremely stony very fine sandy loam, 6 to 12 percent slopes, except that rock outcrops occupy 10 to 20 percent of the surface.

Included in mapping are severely eroded areas in which small gullies are forming and the vegetation is sparse. These areas make up as much as 10 percent of this mapping unit.

This soil is used for pasture. (Capability subclass VIs, nonirrigated; pasture group 1)

Kealakekua Series

The Kealakekua series consists of well-drained silty clay loams that formed in volcanic ash. These are gently sloping to moderately steep soils on uplands

at an elevation ranging from 2,000 to 3,500 feet. The annual rainfall is 80 to 125 inches, most of which falls during the summer months. The mean annual soil temperature is 62° F. The natural vegetation consists of ohia, tree fern, sedges, and kikuyugrass. These soils and Honaunau, Honuaulu, Kahaluu, Kiloa, Manahaa, and Puukala soils are in the same general area.

Kealakekua soils are used mostly for pasture, coffee, macadamia nuts, and woodland. Small acreages are used for truck crops.

Kealakekua silty clay loam, 12 to 20 percent slopes (KPD).—This soil is on the leeward side of Mauna Loa and Hualalai.

In a representative profile the surface layer is dark reddish-brown silty clay loam about 8 inches thick. The subsoil is dark-brown silty clay loam about 23 inches thick. It is underlain by pahoehoe lava bedrock. The surface layer is strongly acid; the subsoil is medium acid. In places the surface is very stony or extremely stony. This soil dehydrates irreversibly into fine gravel-size aggregates.

Representative profile, Kealakekua Quadrangle, lat. 19°31′26″ N. and long. 155°53′10″ W.:

A1—0 to 8 inches, dark reddish-brown (5YR 2/2) silty clay loam; moderate, fine, granular structure; friable, slightly sticky, and plastic; many roots; many fine pores; strongly acid; abrupt, smooth boundary. (7 to 9 inches thick)

B1—8 to 14 inches, dark-brown (7.5YR 3/2) silty clay loam; massive; friable, slightly sticky, plastic, and weakly smeary; many roots; many fine and very fine pores; nearly continuous, gelatinlike coatings on ped surfaces; medium acid; clear, smooth boundary. (6 to 8 inches thick)

B21—14 to 22 inches, dark-brown (7.5YR 3/2) silty clay loam; weak, medium, subangular blocky structure; friable, slightly sticky, plastic, and weakly smeary; common roots; many fine and very fine pores; nearly continuous, gelatinlike coatings on ped surfaces; medium acid; abrupt, wavy boundary. (6 to 10 inches thick)

B22—22 to 31 inches, dark-brown (7.5YR 3/3) silty clay loam; weak, fine, subangular blocky structure; friable, slightly sticky, plastic, and moderately smeary; common roots; many fine pores; nearly continuous, gelatinlike coatings on ped surfaces; basalt fragments make up 20 percent of horizon; medium acid; abrupt, wavy boundary. (7 to 12 inches thick)

IIR—31 inches, hard pahoehoe lava.

The depth to pahoehoe lava bedrock ranges from 20 to 48 inches. The solum ranges from 5YR to 10YR in hue. The B horizon is weakly to moderately smeary. Rock fragments occupy 3 to 35 percent of the soil profile.

Included in mapping are areas in which there are a few stones and rock outcrops. Also included are small areas underlain by Aa lava and small areas of soils that are shallow over bedrock.

Permeability is rapid, runoff is slow, and the erosion hazard is slight. Roots can penetrate to bedrock.

This soil is used mostly for pasture and woodland. Some areas that are transitional to Honuaulu soils are used for coffee, macadamia nuts, and truck crops. (Capability subclass IVe, nonirrigated; pasture group 9; woodland group 7)

Kealakekua very stony silty clay loam, 6 to 20 percent slopes (KRD).—This soil is similar to Kealakekua silty clay loam, 12 to 20 percent slopes, except that stones cover 1 to 3 percent of the surface.

This soil is used for pasture, woodland, coffee, and macadamia nuts. (Capability subclass VIs, nonirrigated; pasture group 9; woodland group 7)

Kealakekua extremely stony silty clay loam, 12 to 20 percent slopes (KSD).—This soil is similar to Kealakekua silty clay loam, 12 to 20 percent slopes, except that stones cover 3 to 15 percent of the surface.

Included in mapping are soils less than 30 inches deep over fragmental Aa lava. They make up about 10 percent of this mapping unit.

This soil is used for pasture and woodland. (Capability subclass VIIs, nonirrigated; pasture group 9; woodland group 7)

Keaukaha Series

The Keaukaha series consists of well-drained, thin organic soils overlying pahoehoe lava bedrock. These soils occupy the low areas of Mauna Loa. They are at an elevation ranging from near sea level to 1,000 feet and receive from 90 inches to more than 150 inches of rainfall annually. Their mean annual soil temperature is between 72° and 74° F. The natural vegetation consists of ohia, tree fern, uluhe fern, and guava. These soils and Kiloa, Olaa, Panaewa, and Papai soils are in the same general area.

Keaukaha soils are used for woodland, pasture, and homesites.

Keaukaha extremely rocky muck, 6 to 20 percent slopes (rKFD).—This soil is near the city of Hilo. It is undulating to rolling and follows the topography of the underlying pahoehoe lava. Rock outcrops occupy about 25 percent of the area.

In a representative profile the surface layer is very dark brown muck about 8 inches thick. It is underlain by pahoehoe lava bedrock. This soil is strongly acid.

Representative profile, Hilo Quadrangle, lat. 19°39′05″ N. and long. 155°03′46″ W.:

O2—8 inches to 0, very dark brown (10YR 2/2) muck; moderate, fine, subangular blocky structure; friable, slightly sticky, slightly plastic, and moderately smeary; many roots; many fine pores; strongly acid; abrupt, wavy boundary. (3 to 10 inches thick)

IIR—0 to 10 inches, pahoehoe lava.

The depth to pahoehoe lava bedrock ranges from 3 to 10 inches. The hue of the O2 horizon ranges from 7.5YR to 10YR.

Included in mapping are small areas of pahoehoe lava flows.

The soil above the lava is rapidly permeable. The pahoehoe lava is very slowly permeable, but water moves rapidly through the cracks. Runoff is medium, and the erosion hazard is slight. In places roots are matted over the pahoehoe lava or extend a few feet into the cracks.

Most of this soil is in native forest. Some areas are cleared and used for pasture. (Capability subclass VIIs, nonirrigated; pasture group 9)

Keei Series

The Keei series consists of well-drained, thin organic soils overlying pahoehoe lava bedrock. These are gently sloping to moderately steep soils on uplands. They

are at an elevation ranging from 1,000 to 3,500 feet and receive from 90 to 150 inches of rainfall annually. Their mean annual soil temperature is between 62° and 65° F. The natural vegetation consists of ohia, tree fern, uluhe fern, and waiwe. These soils and Honaunau, Kahaluu, Kekake, Kona, Lalaau, and Malama soils occur in the same general area.

Keei soils are used mostly for woodland and watershed. Small acreages are cleared and used for pasture.

Keei extremely rocky muck, 6 to 20 percent slopes (rKGD).—This soil is at intermediate elevations on Mauna Loa and Mauna Kea. Rock outcrops occupy 25 to 50 percent of the surface.

In a representative profile the surface layer is very dark brown muck about 10 inches thick. It is underlain by pahoehoe lava bedrock. This soil is strongly acid.

Representative profile, Puu Makaala Quadrangle, lat. 19°37′10″ N. and long. 155°09′40″ W.:

O2—10 inches to 0, very dark brown (7.5YR 2/2) muck; weak, fine, subangular blocky structure; friable, slightly sticky, slightly plastic, and strongly smeary; many roots; strongly acid; abrupt, wavy boundary. (2 to 14 inches thick)

IIR—0 to 10 inches, pahoehoe lava.

The depth to pahoehoe lava bedrock ranges from 2 to 10 inches.

The soil above the lava is rapidly permeable. The lava is very slowly permeable, but water moves rapidly through the cracks. Runoff is medium and the erosion hazard is slight. In places roots are matted over the bedrock or extend a few feet into the cracks.

This soil is used for pasture. (Capability subclass VIIs, nonirrigated; pasture group 9)

Keekee Series

The Keekee series consists of somewhat excessively drained loamy sands that formed in alluvium from volcanic ash and cinders. These soils are nearly level to gently sloping. They are on uplands in the saddle between Mauna Kea and Mauna Loa. The elevation ranges from 5,500 to 8,000 feet, and the annual rainfall is 20 to 30 inches. The mean annual soil temperature is between 50° and 53° F. The natural vegetation consists of mamane, mountain pili, golden-crown beard, and lambsquarters. These soils and Apakuie, Kilohana, and Opihikao soils are in the same general area.

Keekee soils are used for wildlife habitat.

Keekee loamy sand, 0 to 6 percent slopes (KTB).—This soil is in the saddle between Mauna Kea and Mauna Loa. The slope is dominantly less than 3 percent.

A representative profile has a surface layer about 9 inches thick consisting of loamy sand, silt loam, and fine sand. This layer is very dark gray and very dark grayish brown. The subsoil is about 7 inches thick and consists of dark-brown silty clay loam. The substratum is stratified sand and loam. The surface layer is mildly alkaline to moderately alkaline, the subsoil is strongly alkaline, and the substratum is strongly alkaline to very strongly alkaline.

Representative profile, Ahumoa Quadrangle, lat. 19°45′57″ N. and long. 155°34′25″ W.:

A11—0 to 2 inches, very dark gray (10YR 3/1) loamy sand; dark grayish brown (10YR 4/2) when dry; single grain; loose; many roots; many medium and fine interstitial pores; mildly alkaline; abrupt, smooth boundary. (2 to 4 inches thick)

A12—2 to 5 inches, very dark grayish-brown (10YR 3/2) silt loam; brown (10YR 5/3) when dry; massive; slightly hard, very friable, nonsticky, and slightly plastic; few roots along cleavage planes; few fine pores; mildly alkaline; abrupt, smooth boundary. (2 to 3 inches thick)

A13—5 to 9 inches, very dark grayish-brown (10YR 3/2) fine sand; dark grayish brown (10YR 4/2) when dry; single grain; loose; very few roots; very few pores; moderately alkaline; abrupt, smooth boundary. (4 to 5 inches thick)

B2—9 to 16 inches, dark-brown (7.5YR 3/2) silty clay loam; pinkish gray (7.5YR 6/2) when dry; moderate, fine and very fine, subangular blocky structure; hard, friable, slightly hard, slightly sticky, and plastic; very few roots; few fine pores; slight effervescence with dilute hydrochloric acid; moderately alkaline; abrupt, smooth boundary. (6 to 8 inches thick)

C1ca—16 to 24 inches, very dark brown (10YR 2/2) and dark-gray (10YR 4/1) fine sand; dark gray (10YR 4/1) and gray (10YR 6/1) when dry; single grain; loose; very few roots; strong effervescence with dilute hydrochloric acid; strongly alkaline; abrupt, smooth boundary. (6 to 8 inches thick)

C2ca—24 to 32 inches, dark-brown (7.5YR 4/2) loamy sand; pinkish gray (7.5YR 7/2) when dry; single grain; loose; very few roots; top of horizon has a very thin, discontinuous sheet of calcium carbonate; strong effervescence with dilute hydrochloric acid; strongly alkaline; abrupt, smooth boundary. (5 to 9 inches thick)

C3ca—32 to 40 inches, dark yellowish-brown (10YR 3/4) fine sand and coarse sand; grayish brown (10YR 5/2) when dry; single grain; loose; few roots; common gravel and coarse sand coated with calcium carbonate; strong effervescence with dilute hydrochloric acid; very strongly alkaline; abrupt, smooth boundary. (6 to 9 inches thick)

IIC4ca—40 to 60 inches, dark-brown (10YR 3/3) loam; grayish brown (10YR 5/2) when dry; massive; soft, friable, nonsticky, and slightly plastic; few roots; few fine pores; common cobbles and stones coated with calcium carbonate; strong effervescence with dilute hydrochloric acid; strongly alkaline.

The texture of the A horizon ranges from fine sand to silt loam. The horizon of calcium carbonate accumulation occurs at a depth of 12 to 30 inches. In many places the A horizon is covered with windblown deposits.

Included in mapping are small areas that have loose stones on the surface and throughout the profile. These areas are at the mouth of drainageways where coarse material accumulates. Also included are active dunes where vegetation has been disturbed. They are mainly at the base of Mauna Kea.

Permeability is rapid, runoff is slow, and the hazard of soil blowing is moderate to severe. Roots can penetrate to a depth of 3 feet or more.

This soil is now used for wildlife habitat. It was formerly used for sheep grazing. (Capability subclass VIe, nonirrigated; pasture group 14, woodland group 16)

Kehena Series

The Kehena series consists of somewhat poorly drained silty clay loams that formed in volcanic ash. These are gently sloping to moderately sloping soils on uplands

at an elevation ranging from 1,700 to 2,500 feet. They receive 100 to 150 inches of rainfall annually, and their mean annual soil temperature is between 66° and 68° F. The natural vegetation consists of ohia, tree fern, hilograss, and wetland sedge. These soils and Amalu, Kahua, Niulii, and Palapalai soils are in the same general area.

Kehena soils are used for pasture, for woodland, and for wildlife habitat.

Kehena silty clay loam, 6 to 12 percent slopes (KVC).—This undulating to rolling soil is on the windward side of the Kohala Mountains.

In a representative profile the surface layer is dark-brown silty clay loam about 6 inches thick. The lower part of the surface layer is mottled. The subsoil is dark-brown to very dark grayish-brown silty clay loam about 20 inches thick. Pahoehoe bedrock is at a depth of about 26 inches. The surface layer is very strongly acid, and the subsoil is very strongly acid to strongly acid. This soil dehydrates irreversibly into fine gravel-size aggregates.

Representative profile, Hawi Quadrangle, lat. 20°09′59″ N. and long. 155°47′44″ W.:

A11—0 to 2 inches, dark-brown (7.5YR 3/2) silty clay loam; moderate, fine and very fine, granular structure; friable, slightly sticky, and plastic; roots matted; many very fine pores; very strongly acid; clear, smooth boundary. (2 to 3 inches thick)

A12—2 to 6 inches, dark-brown (7.5YR 3/2) silty clay loam; common, fine, distinct mottles of dark reddish brown (5YR 3/2 and 3/4); strong, fine and very fine, granular structure; friable, slightly sticky, and plastic; many roots; many fine and very fine pores; common fine concretions of iron oxide; very strongly acid; abrupt, smooth boundary. (4 to 6 inches thick)

B1—6 to 15 inches, dark-brown (7.5YR 3/4) silty clay loam; moderate, medium and fine, subangular blocky structure; friable, slightly sticky, plastic, and weakly smeary; many roots; many fine and very fine pores; thick, gelatinlike coatings on peds; very strongly acid; clear, smooth boundary. (7 to 10 inches thick)

B21—15 to 22 inches, dark-brown (10YR 3/3) silty clay loam; moderate, medium and fine, subangular blocky structure; friable, slightly sticky, plastic, and strongly smeary; many roots; many fine and very fine pores; thick, gelatinlike coatings on peds; few gravel-size rock fragments; strongly acid; clear, smooth boundary. (6 to 8 inches thick)

B22—22 to 26 inches, very dark grayish-brown (10YR 3/2) silty clay loam; moderate, fine, subangular blocky structure; friable, slightly sticky, plastic, and strongly smeary; many roots; many fine and very fine pores; common basalt fragments; roots matted over basalt; strongly acid; abrupt, wavy boundary. (2 to 8 inches thick)

IIR—26 inches, pahoehoe bedrock.

The depth to bedrock is 20 to 48 inches. At the lower elevations, the A horizon is thinner and has less pronounced mottling. The concretions of iron oxide are fewer in the drier areas of this soil. In places the B horizon has prominent mottles.

Included in mapping are small areas of better drained soils that have convex slopes.

Permeability is moderately rapid, runoff is slow, and the erosion hazard is slight. Roots can penetrate to bedrock.

This soil is used for pasture and woodland and for wildlife habitat. (Capability subclass IIIe, nonirrigated; pasture group 8; woodland group 6)

Kekake Series

The Kekake series consists of well-drained, thin organic soils over pahoehoe lava bedrock. These soils are gently sloping to moderately steep. They are on uplands at an elevation ranging from 3,500 to 7,000 feet, and they receive from 50 to 80 inches of rainfall annually. Their mean annual soil temperature is between 52° and 55° F. The natural vegetation consists of ohia, tree fern, amaumau fern, ieie vine, and mamaki. These soils and Honaunau, Keei, and Mawae soils occur in the same general area.

Kekake soils are used mainly for watershed and for wildlife habitat. Small acreages are used for pasture.

Kekake extremely rocky muck, 6 to 20 percent slopes (rKHD).—This soil is at intermediate elevations on Mauna Loa and Hualalai. Rock outcrops occupy 25 to 50 percent of the surface area.

In a representative profile the surface layer is black muck about 4 inches thick. It is underlain by pahoehoe lava bedrock. This soil is strongly acid.

Representative profile, Honaunau Quadrangle, lat. 19°28′40″ N. and long. 155°51′50″ W.:

O2—4 inches to 0, black (5YR 2/1) muck; weak, fine, granular structure; very friable, slightly sticky, slightly plastic, and moderately smeary; many roots; many fine pores; few pebbles and cobbles; strongly acid; abrupt, wavy boundary.

IIR—0 to 10 inches, pahoehoe lava.

The thickness of the O2 horizon ranges from 2 to 10 inches.

The soil above the lava is rapidly permeable. The lava is very slowly permeable, but water moves rapidly through the cracks. Runoff is medium, and the erosion hazard is slight. Roots are matted over the bedrock or extend a few feet into the cracks.

This soil is used mainly for watershed and for wildlife habitat. Small areas are used for pasture. (Capability subclass VIIs, nonirrigated; pasture group 12)

Kikoni Series

The Kikoni series consists of well-drained very fine sandy loams that formed in volcanic ash. These soils are nearly level to moderately sloping. They are on the Waimea plains at an elevation ranging from 2,600 to 3,600 feet. They receive 35 to 70 inches of rainfall annually, and their mean annual soil temperature is between 64° and 66° F. The natural vegetation consists of bermudagrass, hilograss, rattail, and kikuyugrass. These soils and Maile, Punohu, and Waimea soils are in the same general area.

Kikoni soils are used for pasture, truck crops, and wildlife habitat.

Kikoni very fine sandy loam, 3 to 12 percent slopes (KXC).—This soil is on the Waimea plains on the leeward side of Mauna Kea.

In a representative profile the surface layer is very dark brown very fine sandy loam about 6 inches thick. The subsoil is about 44 inches thick and consists of dark-brown and dark reddish-brown very fine sandy loam and silt loam. The substratum is fragmental Aa lava. The surface layer is neutral, and the subsoil is mildly alkaline. The surface is extremely stony in places.

Representative profile, Kukuihaele Quadrangle, lat. 20°00′44″ N. and long. 155°36′08″ W.:

A1—0 to 6 inches, very dark brown (7.5YR 2/2) very fine sandy loam; dark brown (7.5YR 3/2) when dry; strong, fine and medium, granular structure; soft, friable, nonsticky, and nonplastic; many roots; many very fine and fine pores; neutral; abrupt, smooth boundary. (5 to 7 inches thick)

B21—6 to 11 inches, dark-brown (7.5YR 3/3) very fine sandy loam; dark yellowish brown (10YR 4/4) when dry; massive; soft, very friable, nonsticky, and nonplastic; many roots; many very fine and fine pores; pockets of white material that may be remnants of old land snails; neutral; gradual, smooth boundary. (4 to 6 inches thick)

B22—11 to 15 inches, dark-brown (7.5YR 3/2) very fine sandy loam; dark yellowish brown (10YR 4/4) when dry; massive; soft, very friable, nonsticky, and nonplastic; many roots; many very fine and fine pores; common pockets of material that has strong, fine, subangular blocky structure; mildly alkaline; gradual, smooth boundary. (4 to 9 inches thick)

B23—15 to 25 inches, dark-brown (7.5YR 3/3) very fine sandy loam; dark brown (7.5YR 4/4) when dry; massive; pockets of material that has strong, fine, subangular blocky structure; soft, very friable, nonsticky, and nonplastic; many roots; many fine and medium pores; mildly alkaline; gradual, smooth boundary. (5 to 10 inches thick)

IIB24b—25 to 50 inches, dark reddish-brown (5YR 3/2) silt loam; very dark brown (10YR 2/2) when dry; strong, very fine and fine, subangular blocky structure; extremely hard, firm, nonsticky, and slightly plastic; common roots; many very fine and fine pores; common pockets of dark yellowish-brown (10YR 3/4) material similar to pockets in above horizon; common basalt fragments of gravel size; mildly alkaline; abrupt, wavy boundary. (20 to 30 inches thick)

IIIC—50 inches, mostly fragmental Aa lava; soil material from above fills the interstices.

The depth to Aa lava is 4 to 8 feet. The solum ranges from 10YR to 5YR in hue. The texture of the A horizon ranges from silt loam to very fine sandy loam. In the wetter areas the B horizon is weakly smeary and dehydrates irreversibly.

Included in mapping are small areas of Maile soils.

Permeability is moderately rapid, runoff is slow, and the erosion hazard is slight to moderate. The available water capacity is about 1.6 inches per foot of soil. Roots can penetrate to a depth of 4 feet or more.

This soil is used for pasture and for wildlife habitat. (Capability subclass IIIe, irrigated, and IIIe, nonirrigated; pasture group 12; woodland group 9)

Kikoni very fine sandy loam, 0 to 3 percent slopes (KfA).—This soil is on the Waimea plains. The surface layer has lost its strong granular structure where it has been continuously cultivated. In some areas gravel is in the lower part of the profile.

This soil is used for truck crops. (Capability class I, irrigated, and capability subclass IIc, nonirrigated; pasture group 12; woodland group 9)

Kikoni extremely stony very fine sandy loam, 6 to 12 percent slopes (KYC).—This soil is similar to Kikoni very fine sandy loam, 3 to 12 percent slopes, except that stones cover 3 to 15 percent of the surface. It occurs as long, narrow bodies over old lava flows.

This soil is used for pasture and for wildlife habitat. (Capability subclass VIIs, nonirrigated; pasture group 12; woodland group 9)

Kilauea Series

The Kilauea series consists of somewhat excessively drained gravelly sands that formed in volcanic ash, pumice, and cinders. These are moderately sloping soils on uplands. They are at an elevation ranging from 200 to 4,000 feet and receive from 20 to 60 inches of rainfall annually. The mean annual soil temperature is between 65° and 68° F. The natural vegetation is sparse and consists mainly of scrub, ohia, oheloberry, puakeawe, and broomsedge. These soils and Heake, Kona, and Manu soils are in the same general area.

Kilauea soils are used for recreation areas. Most of the acreage is in the Hawaii Volcanoes National Park.

Kilauea extremely gravelly sand, 6 to 12 percent slopes (rKUC).—This soil is on the leeward side of the Kilauea Crater.

In a representative profile the surface layer is dark-brown extremely gravelly sand about 8 inches thick. It is underlain by stratified layers of volcanic sand, gravel, cinders, and pumice. The surface layer is neutral. The underlying material is moderately alkaline.

Representative profile, Kilauea Crater Quadrangle, lat. 19°24′12″ N. and long. 155°31′40″ W.:

C1—0 to 8 inches, dark-brown (10YR 3/3) extremely gravelly sand; gray (10YR 5/1) when dry; single grain; loose; many, fine, interstitial pores; very few roots; neutral; abrupt, smooth boundary. (6 to 10 inches thick)

C2—8 to 11 inches, very dark grayish-brown (10YR 3/2) fine sandy loam; gray (10YR 5/1) when dry; moderate, medium, platy structure; very firm, nonsticky, and nonplastic; very few roots; few fine pores; moderately alkaline; abrupt, smooth boundary. (2 to 4 inches thick)

C3—11 to 17 inches, dark-gray (10YR 4/1) gravelly fine sand; gray (10YR 5/1) when dry; single grain; loose; many interstitial pores; very few roots; alternating layers of loose gravel 2 to 5 millimeters in size; stones and cobbles comprise about one percent of this layer; moderately alkaline; abrupt, wavy boundary. (5 to 8 inches thick)

C4—17 to 60 inches, very dark grayish brown (2.5Y 3/2) gravelly fine sand; dark grayish brown (2.5Y 4/2) when dry; single grain; loose; many, fine, interstitial pores; very few roots; moderately alkaline.

The depth to bedrock is 20 inches to more than 60 inches. In places a weakly to strongly cemented thin crust has developed on the surface. The C2 horizon ranges from loam to sandy loam in texture.

Included in mapping are rock outcrops and areas of shallow sandy soils less than 20 inches deep. In some areas small, active dunes are common.

Permeability is rapid. Runoff is slow. The hazard of soil blowing is moderate. Vegetation is sparse because of the recent nature of this soil.

This soil is used for recreation areas. (Capability subclass VIIIs, nonirrigated)

Kiloa Series

The Kiloa series consists of well-drained, thin, extremely stony organic soils over fragmental Aa lava. The soils are gently sloping to moderately steep. They are on uplands at an elevation ranging from 1,000 to 4,000 feet. They receive 90 to 150 inches of rainfall annually, and their mean annual soil temperature is

between 64° and 67° F. The natural vegetation consists of ohia, tree fern, and bracken fern. These soils and Akaka, Honaunau, Kahaluu, Kealakekua, Keaukaha, Mawae, and Papai soils are in the same general area.

Kiloa soils are used for woodland and pasture and for wildlife habitat.

Kiloa extremely stony muck, 6 to 20 percent slopes (rKXD).—This soil is at intermediate elevations on Mauna Loa and Hualalai.

In a representative profile the surface layer is very dark brown extremely stony muck about 10 inches thick. It is underlain by fragmental Aa lava. Slightly weathered ash and cinders are in the voids of the lava. The profile is strongly acid.

Representative profile, Puu Makaala Quadrangle, lat. 19°35′50″ N. and long. 155°08′49″ W.:

O2—10 inches to 0, very dark brown (7.5YR 2/2) extremely stony muck; weak, fine, subangular blocky structure; friable, slightly sticky, slightly plastic, and strongly smeary; many roots; many pores; many Aa lava fragments of gravel to stone size; strongly acid; abrupt, wavy boundary. (3 to 12 inches thick)

IIC—0 to 10 inches, fragmental Aa lava; slightly weathered volcanic ash and cinders in small pockets; strongly acid.

The thickness of the O2 horizon ranges from 3 to 12 inches, and the structure is weak to moderate.

Included in mapping are small areas of Lalaau and Keei soils.

Permeability is rapid, runoff is very slow, and the erosion hazard is slight. Roots can penetrate to a depth of 2 feet or more in the cracks of the lava.

This soil is used for woodland and pasture. (Capability subclass VIIs, nonirrigated; pasture group 9; woodland group 13)

Kilohana Series

The Kilohana series consists of somewhat excessively drained loamy fine sands that formed in volcanic ash, sand, and cinders. These soils are moderately steep. They are on uplands at an elevation ranging from 5,000 to 6,500 feet. They receive from 20 to 40 inches of rainfall annually and their soil temperature is between 50° and 53° F. The natural vegetation consists of brome fescue, orchardgrass, hardstem lovegrass, and mamane. These soils and Apakuie, Huikau, Keekee, and Laumaia soils are in the same general area.

Kilohana soils are used for pasture, wildlife habitat, and recreation areas.

Kilohana loamy fine sand, 12 to 20 percent slopes (KZD).—This soil is high on the leeward side of Mauna Kea.

In a representative profile the surface layer is very dark brown loamy fine sand about 11 inches thick. Below the surface layer is very dark gray fine sand. It is underlain by volcanic ash, sand, and cinders at a depth of about 42 inches. In some places there are cemented layers of sand in the lower part of the profile. The profile is mildly alkaline throughout.

Representative profile, Keamuku Quadrangle, lat. 19°48′19″ N. and long. 155°37′55″ W.:

A11—0 to 5 inches, very dark brown (10YR 2/2) loamy fine sand; dark brown (10YR 4/3) when dry; single grain; loose; many roots; mildly alkaline; clear, wavy boundary. (4 to 6 inches thick)

A12—5 to 11 inches, very dark brown (7.5YR 2/2) loamy fine sand; dark grayish brown (10YR 4/2) when dry; single grain; loose; many roots; many interstitial pores; mildly alkaline; abrupt, wavy boundary. (5 to 7 inches thick)

B2—11 to 16 inches, dark-brown (7.5YR 3/4) fine sand; dark yellowish brown (10YR 4/4) when dry; single grain; loose; many roots; many interstitial pores; mildly alkaline; abrupt, wavy boundary. (4 to 10 inches thick)

C1—16 to 42 inches, very dark gray (5YR 3/1) fine sand; yellowish brown (10YR 5/6) when dry; single grain; loose; common roots decreasing to few with increasing depth; many fine pores; mildly alkaline; abrupt, smooth boundary. (23 to 28 inches thick)

C2—42 inches, semiconsolidated volcanic ash, sand, and cinders; colors similar to those of the above horizon.

The depth to bedrock ranges from 4 to 8 feet. The texture of the A horizon ranges from loam to loamy sand. In places the C1 horizon is underlain by cinders and black sand.

Included in mapping are small areas of Apakuie soils.

Permeability is rapid, runoff is slow, and the erosion hazard is slight. Roots can penetrate to a depth of 3 feet or more.

This soil is used for pasture, wildlife habitat, and recreation areas. (Capability subclass VIe, nonirrigated; pasture group 14; woodland group 16)

Kohala Series

The Kohala series consists of well-drained silty clays that formed in material from basic igneous rock influenced by volcanic ash. These soils are nearly level to steep. They occupy the coastal areas of the Kohala Mountains at an elevation ranging from near sea level to 1,500 feet. They receive from 40 to 60 inches of rainfall annually, and their mean annual soil temperature is between 72° and 74° F. The natural vegetation consists of Koa haole, lantana, guava, and Christmas berry. These soils and Ainakea and Hawi soils are in the same general area.

Kohala soils are used mostly for sugarcane. Small areas are used for pasture, orchards, and truck crops.

Kohala silty clay, 0 to 3 percent slopes (KhA).—This soil is on the windward side of the Kohala Mountains. It is dissected by a few, deep, narrow gulches.

In a representative profile the surface layer is very dark grayish-brown and dark-brown silty clay about 14 inches thick. The subsoil is about 25 inches thick and consists of dark-brown to dark yellowish-brown silty clay loam and silty clay. The substratum is weathered basic igneous rock. The profile is slightly acid in the surface layer, slightly acid and neutral in the subsoil, and neutral in the substratum.

Representative profile, Hawi Quadrangle, lat. 20°14′35″ N. and long. 155°49′30″ E.:

Ap1—0 to 7 inches, very dark grayish-brown (10YR 3/2) silty clay; dark grayish brown (10YR 4/2) when dry; moderate, fine, granular structure; extremely hard, friable, sticky, and plastic; many roots; many fine pores; moderate effervescence with hydrogen peroxide; slightly acid; abrupt, smooth boundary. (6 to 9 inches thick)

Ap2—7 to 14 inches, dark-brown (10YR 3/3) silty clay; dark grayish brown (10YR 4/2) when dry; weak, coarse, prismatic structure that breaks to moderate.

medium and fine, subangular and angular blocky structure; very hard, friable, sticky, and plastic; many roots along prism faces; very compact in places; common pressure cutans; black coatings in root channels; common, very fine, red rock fragments; moderate effervescence with hydrogen peroxide; slightly acid; abrupt, smooth boundary. (7 to 10 inches thick)

B21—14 to 27 inches, dark-brown (10YR 3/3) silty clay loam; dark brown (10YR 4/3) when dry; moderate, medium and coarse, subangular blocky structure that breaks to moderate, fine, subangular blocky structure; hard, friable, slightly sticky, and plastic; few roots; many very fine pores; very compact in place; few pressure cutans; slight effervescence with hydrogen peroxide; slightly acid; gradual, smooth boundary. (6 to 13 inches thick)

B22—27 to 39 inches, dark yellowish-brown (10YR 3/4) silty clay; dark brown (10YR 4/3) when dry; strong, fine and very fine, subangular blocky structure; hard, friable, sticky, and plastic; few roots; few pressure cutans; few gravel-size fragments of saprolite; few black coatings; no effervescence with hydrogen peroxide; neutral; clear, smooth boundary. (10 to 15 inches thick)

C—39 inches, variegated, weathered basalt; firm, nonsticky, nonplastic, and weakly smeary; no effervescence with hydrogen peroxide; no roots; neutral.

The depth to weathering basalt is more than 36 inches. The hue of the solum ranges from 7.5YR to 10YR. In the A horizon effervescence with hydrogen peroxide ranges from moderate to strong.

Permeability is moderately rapid, runoff is slow, and the erosion hazard is slight. The available water capacity is about 1.7 inches per foot of soil. Roots can penetrate to a depth of 5 feet or more.

This soil is used for irrigated sugarcane. (Capability class I, irrigated, and capability subclass IIc, nonirrigated; sugarcane group 1; pasture group 5; woodland group 4)

Kohala silty clay, 3 to 12 percent slopes (KhC).—This soil is similar to Kohala silty clay, 0 to 3 percent slopes, except for the steeper slopes. Runoff is slow to medium, and the erosion hazard is slight to moderate.

This soil is used mostly for irrigated sugarcane. Small areas are used for pasture, orchards, and truck crops. (Capability subclass IIIe, irrigated, and IIIe, nonirrigated; sugarcane group 1; pasture group 5; woodland group 4)

Kohala silty clay, 12 to 20 percent slopes (KhD).—This soil is similar to Kohala silty clay, 0 to 3 percent slopes, except for the steeper slopes. Runoff is medium, and the erosion hazard is moderate.

Included in mapping are small areas of soils that have slopes greater than 20 percent and are less than 30 inches deep. These included soils are in drainageways that lead to the gulches.

This soil is used mostly for irrigated sugarcane. Small areas are used for pasture and orchards. (Capability subclass IVe, irrigated, and IVe, nonirrigated; sugarcane group 1; pasture group 5; woodland group 4)

Kohala silty clay, 20 to 35 percent slopes (KhE).—This soil occurs along drainageways. Runoff is rapid, and the erosion hazard is severe. Included in mapping are small areas of soils that have slopes greater than 35 percent.

This soil is used for sugarcane and pasture. (Capability subclass VIe, irrigated, and VIe, nonirrigated; sugarcane group 1; pasture group 5; woodland group 4)

Kona Series

The Kona series consists of well-drained, thin organic soils over pahoehoe lava bedrock. These are gently sloping to moderately steep soils on uplands. They are at an elevation ranging from 1,000 to 3,500 feet and receive from 60 to 90 inches of rainfall annually. Their mean annual soil temperature is between 64° and 66° F. The natural vegetation consists of guava, Christmas berry, californiagrass, and kikuyugrass. These soils and Kahaluu, Keei, Kilauea, Manu, Opihikao, and Puna soils are in the same general area.

Kona soils are used mostly for pasture and watershed. A small acreage is used for coffee and macadamia nuts.

Kona extremely rocky muck, 6 to 20 percent slopes (rKYD).—This soil is at intermediate elevations on Mauna Loa and Hualalai. Rock outcrops occupy 25 to 50 percent of the surface.

In a representative profile the surface layer is very dark brown muck about 5 inches thick. It is underlain by pahoehoe lava bedrock. The surface layer is slightly acid.

Representative profile, Pohue Bay Quadrangle, lat. 19°07′25″ N. and long. 155°05′45″ W.:

O2—5 inches to 0, very dark brown (7.5YR 2/2) muck; moderate, medium and fine, subangular blocky structure; friable, slightly sticky, slightly plastic, and weakly smeary; matted roots; many fine pores; 30 to 50 percent pahoehoe outcrop; slightly acid; abrupt, smooth boundary. (2 to 7 inches thick)

IIR—0 to 10 inches, pahoehoe lava.

The depth to pahoehoe lava bedrock ranges from 2 to 7 inches.

Permeability is rapid in the soil, and water moves rapidly through the cracks of the lava. Runoff is medium, and the erosion hazard is slight. Roots are matted over the bedrock or extend a few feet into the cracks.

This soil is used mostly for pasture and watershed. Small areas are used for coffee and macadamia nuts. (Capability subclass VIIs; pasture group 7)

Kukaiau Series

The Kukaiau series consists of well-drained silty clay loams that formed in volcanic ash. These soils are gently sloping to steep. They are on uplands at an elevation ranging from 500 to 1,500 feet and receive from 70 to 100 inches of rainfall annually. Their mean annual soil temperature is between 67° and 69° F. The natural vegetation consists of hilograss, kaimi clover, guava, and ohia. These soils and Honokaa, Ookala, and Paauhau soils are in the same general area.

Kukaiau soils are used mostly for sugarcane. Small areas are used for truck crops, macadamia nuts, and pasture.

Kukaiau silty clay loam, 6 to 12 percent slopes (KuC).—This soil is low on the windward side of Mauna Kea. It is dissected by many, deep, narrow gulches.

In a representative profile the surface layer is very dark grayish-brown silty clay loam about 10 inches thick. The subsoil is dark-brown silty clay loam about 40 inches thick. It is underlain by basalt. The surface layer is extremely acid, and the subsoil is medium to slightly

acid. This soil dehydrates irreversibly into aggregates the size of fine sand.

Representative profile, Kukuihaele Quadrangle, lat. 20°05′20″ N. and long. 155°30′28″ E.:

Ap—0 to 10 inches, very dark grayish-brown (10YR 3/2) silty clay loam; strong, medium and fine, subangular blocky structure; slightly sticky and slightly plastic; many roots; many very fine pores; extremely acid; abrupt, wavy boundary. (8 to 12 inches thick)

B1—10 to 16 inches, dark-brown (7.5YR 3/2) silty clay loam; weak, medium and fine, subangular blocky structure; friable, slightly sticky, and slightly plastic; many roots; many medium and fine pores; many sugarlike coatings on peds; medium acid; abrupt, wavy boundary. (6 to 10 inches thick)

B21—16 to 30 inches, dark-brown (7.5YR 3/3) silty clay loam; moderate, medium and fine, subangular blocky structure; friable, slightly sticky, plastic, and weakly smeary; many roots; many medium and fine pores; many sugarlike coatings on peds; slightly acid; clear, wavy boundary. (12 to 20 inches thick)

B22—30 to 38 inches, dark-brown (7.5YR 3/2) silty clay loam; moderate, medium and fine, subangular blocky structure; friable, slightly sticky, plastic, and weakly smeary; few roots; many fine and very fine pores; many sugarlike coatings on peds; few gravel-size fragments of basalt (less than 5 percent); slightly acid; abrupt, wavy boundary. (6 to 10 inches thick)

B23—38 to 50 inches, dark-brown (10YR 3/3) very cobbly silty clay loam; moderate, medium and fine, subangular blocky structure; friable, slightly sticky, plastic, and moderately smeary; few roots; many medium and fine pores; slightly acid; pebbles and cobbles of basalt make up 80 percent of the horizon.

IIR—50 inches, basalt.

The depth to unconforming bedrock is 4 to 6 feet. The hue of the solum ranges from 5YR to 10YR. The B horizon is more smeary with increasing elevation and rainfall. This horizon dehydrates irreversibly into very hard, dark-brown or black aggregates the size of sand and silt.

Permeability is moderately rapid, runoff is slow, and the erosion hazard is slight. Roots can penetrate to a depth of 5 feet or more.

This soil is used mostly for sugarcane. Small areas are used for truck crops, macadamia nuts, and pasture. (Capability subclass IIIe, nonirrigated; sugarcane group 3; pasture group 7; woodland group 5)

Kukaiau silty clay loam, 12 to 20 percent slopes (KuD).—This soil is similar to Kukaiau silty clay loam, 6 to 12 percent slopes, except for the steeper slopes. Runoff is medium and the erosion hazard is moderate.

This soil is used mainly for sugarcane. Small areas are used for macadamia nuts and pasture. (Capability subclass IVe, nonirrigated; sugarcane group 3; pasture group 7; woodland group 5)

Kukaiau silty clay loam, 20 to 35 percent slopes (KuE).—This soil is similar to Kukaiau silty clay loam, 6 to 12 percent slopes, except for the steeper slopes. Runoff is rapid, and the erosion hazard is severe. Included in mapping are small areas in drainageways that have very steep slopes.

This soil is used mostly for sugarcane. Small areas are used for pasture. (Capability subclass VIe, nonirrigated; sugarcane group 3; pasture group 7; woodland group 5)

Kukaiau silty clay loam, moderately shallow, 12 to 20 percent slopes (KwD).—This soil is in the Kukuihaele area. In addition to having steeper slopes than Kukaiau silty clay loam, 6 to 12 percent slopes, this soil has a red surface layer, is more acid, and is only 20 to 30 inches deep to weathered basalt. The erosion hazard is moderate.

This soil is used for sugarcane. (Capability subclass IVe, nonirrigated; sugarcane group 3; pasture group 7; woodland group 5)

Lalaau Series

The Lalaau series consists of well drained, thin, extremely stony mucky soils over recent Aa lava. These soils are gently sloping to moderately steep. They are on uplands at an elevation ranging from 3,500 to 7,000 feet and receive from 90 inches to more than 150 inches of rainfall annually. Their mean annual soil temperature is between 56° and 59° F. The natural vegetation consists of ohia, tree fern, amaumau fern, uluhe fern, and puakeawe. These soils and Akaka, Kahaluu, Keei, and Piihonua soils are in the same general area.

Lalaau soils are used for woodland, wildlife habitat, and watershed.

Lalaau extremely stony muck, 6 to 20 percent slopes (rLLD).—This undulating to rolling soil is at intermediate elevations on Mauna Loa.

In a representative profile the surface layer is very dark brown extremely stony muck about 3 inches thick. It is underlain by fragmental Aa lava. The surface layer is very strongly acid.

Representative profile, Upper Piihonua Quadrangle, lat. 19°41′40″ N. and long. 155°17′10″ W.:

O2—3 inches to 0, very dark brown (10YR 2/2) extremely stony muck; weak, very fine, granular structure; friable, slightly sticky, slightly plastic, and strongly smeary; many roots; many fine pores; very strongly acid; Aa lava makes up about 25 to 50 percent of the horizon by volume; abrupt, wavy boundary. (2 to 8 inches thick)

IIC—0 to 10 inches, fragmental Aa lava; small amount of material from above in spaces between the Aa lava fragments.

The O2 horizon ranges from 2 to 8 inches in thickness and from 7.5YR to 10YR in hue.

Permeability is rapid, runoff is slow, and the erosion hazard is slight. Roots can extend to a depth of 2 feet or more in the cracks of the lava.

This soil is used mostly for woodland and watershed and for wildlife habitat. Small areas are used for pasture. (Capability subclass VIIs, nonirrigated; pasture group 10; woodland group 14)

Laumaia Series

The Laumaia series consists of well-drained silt loams that formed in volcanic ash. These soils are gently sloping to moderately steep. They are on uplands at an elevation ranging from 5,500 to 8,000 feet. They receive from 35 to 70 inches of rainfall annually, and their mean annual soil temperature is between 52° and 54° F. The natural vegetation consists of sweet vernal, yorkshire fog, carpetgrass, and white clover. These soils and Hanipoe, Kilohana, and Puu Oo soils are in the same general area.

Laumaia soils are used for pasture.

Laumaia silt loam, 6 to 20 percent slopes (LAD).—This soil is high on the windward side of Mauna Kea. It is

undulating to rolling and has a dominant gradient of 10 percent.

In a representative profile the surface layer is very dark brown and dark-brown silt loam about 13 inches thick. The subsoil is very dark grayish-brown and dark-brown silt loam about 23 inches thick. The substratum consists of weakly cemented sandy layers. The surface layer is medium acid, and the subsoil is strongly acid. The surface is extremely stony in places.

Representative profile, Puu Akala Quadrangle, lat. 19°45′50″ N. and long. 155°21′58″ W.:

A11—0 to 4 inches, very dark brown (10YR 2/2) silt loam; moderate, fine, granular structure; slightly hard, friable, slightly sticky, and slightly plastic; many roots; many very fine pores; medium acid; abrupt, smooth boundary. (3 to 5 inches thick)

A12—4 to 8 inches, dark-brown (7.5YR 3/3) silt loam; massive; slightly hard, friable, slightly sticky, and plastic; many roots; many very fine pores; medium acid; abrupt, smooth boundary. (3 to 4 inches thick)

A3—8 to 13 inches, dark-brown (7.5YR 3/2) silt loam; massive; slightly hard, friable, slightly sticky, and plastic; common roots; many very fine pores; few pockets of dark reddish-brown (2.5YR 3/4) soil; strongly acid; abrupt, wavy boundary. (4 to 7 inches thick)

B21—13 to 19 inches, very dark grayish-brown (10YR 3/2) silt loam; weak, fine, subangular blocky structure; hard, friable, slightly sticky, plastic, and weakly smeary; common roots; many very fine pores; strongly acid; abrupt, wavy boundary. (5 to 9 inches thick)

B22—19 to 36 inches, dark-brown (7.5YR 3/3) silt loam; massive; hard, friable, slightly sticky, plastic, and weakly smeary; common roots; many very fine pores; cinders 2 to 5 millimeters in size make up about 30 to 40 percent of this horizon; strongly acid; abrupt, smooth boundary. (13 to 17 inches thick)

IIC—36 to 55 inches, very dark grayish-brown (10YR 3/2) and black (5YR 2/1) fine volcanic sand that has a salt and pepper appearance; massive; hard, firm, nonsticky, and nonplastic; weakly cemented; no roots; roots matted on surface of horizon; lower part of horizon is loose; medium acid.

The depth to bedrock ranges from 3 to 6 feet. The A horizon ranges from 5YR to 10YR in hue. The structure of the A11 horizon is weak to moderate. In some places there is a thin, discontinuous, red layer immediately below the A horizon.

Included in mapping on some ridgetops are soils that are very shallow to shallow.

Permeability is moderately rapid, runoff is medium, and the erosion hazard is moderate.

This soil is used for pasture. (Capability subclass IVe, nonirrigated; pasture group 13; woodland group 10)

Laumaia extremely stony silt loam, 6 to 12 percent slopes (LUC).—This soil is similar to Laumaia silt loam, 6 to 20 percent slopes, except that stones cover 3 to 15 percent of the surface. The erosion hazard is slight, and runoff is slow.

This soil is used for pasture. (Capability subclass VIIs, nonirrigated; pasture group 13; woodland group 10)

Lava Flows, Aa

Lava flows, Aa (rLV), has been mapped as a miscellaneous land type. This lava has practically no soil covering and is bare of vegetation, except for mosses, lichens, ferns, and a few small ohia trees. It is at an elevation ranging from near sea level to 13,000 feet and receives from 10 to 250 inches of rainfall annually. It is associated with pahoehoe lava flows and many soils.

This lava is rough and broken (fig. 7). It is a mass of clinkery, hard, glassy, sharp pieces piled in tumbled heaps. In areas of high rainfall, it contributes substantially to the underground water supply and is used for watershed. (Capability subclass VIIIs, nonirrigated)

Lava Flows, Pahoehoe

Lava flows, pahoehoe (rLW), has been mapped as a miscellaneous land type. This lava has a billowy, glassy surface that is relatively smooth (fig. 8). In some areas, however, the surface is rough and broken, and there are hummocks and pressure domes.

Pahoehoe lava has no soil covering and is typically bare of vegetation except for mosses and lichens. In the areas of higher rainfall, however, scattered ohia trees, ohelo berry, and aalii have gained a foothold in cracks and crevices.

This miscellaneous land type is at an elevation from sea level to 13,000 feet. The annual rainfall ranges from 10 inches to more than 140 inches.

Some flat slabs of pahoehoe lava are used as facings on buildings and fireplaces. In areas of higher rainfall, this lava contributes to the ground-water supply. (Capability subclass VIIIs, nonirrigated)

Mahukona Series

The Mahukona series consists of well-drained silty clay loams that formed in volcanic ash and basalt residuum. These are undulating to rolling soils that occupy leeward coastal areas of the Kohala Mountains. They are at an elevation ranging from near sea level to 550 feet and receive from 20 to 30 inches of rainfall annually. Their mean annual soil temperature is between 72° and 75° F. The natural vegetation consists of kiawe, uhaloa, ilima, swollen fingergrass, and bermudagrass. These soils and Hawi, Kawaihae, and Puu Pa soils are in the same general area.

Mahukona soils are used for pasture and irrigated sugarcane.

Mahukona very stony silty clay loam, 6 to 12 percent slopes (MKC).—This soil occupies coastal areas on the Kohala Mountains. The slope is dominantly 10 percent.

In a representative profile the surface layer is dark reddish-brown very stony silty clay loam about 6 inches thick. The subsoil is dark reddish-brown and dusky-red silty clay loam about 30 inches thick. The substratum is hard saprolite. The surface layer is medium acid. The subsoil is slightly acid to neutral.

Representative profile, Mahukona Quadrangle, lat. 20°12′07″ N. and long. 155°53′34″ W.:

A1—0 to 6 inches, dark reddish-brown (5YR 3/3) very stony silty clay loam; dark reddish brown (5YR 3/4) when dry; weak, very fine, granular structure; soft, friable, slightly sticky, and plastic; many fine roots; many fine pores; about 1 to 2 percent of surface covered with stones; strong effervescence with hydrogen peroxide; medium acid; clear, smooth boundary. (5 to 7 inches thick)

Figure 7.—Aa lava flow of the year 1843 in the saddle between Mauna Loa and Mauna Kea.

B1—6 to 12 inches, dark reddish-brown (5YR 3/3) silty clay loam; dark reddish brown (5YR 3/4) when dry; weak, medium and fine, subangular blocky structure; hard, friable, slightly sticky, and plastic; many fine roots; many very fine pores; strong effervescence with hydrochloric acid; many black specks; slightly acid; clear, smooth boundary. (5 to 7 inches thick)

B21—12 to 19 inches, dark reddish-brown (5YR 3/3) silty clay loam; dark reddish brown (5YR 3/4) when dry; moderate, fine, prismatic structure; slightly hard, friable, slightly sticky, and plastic; compact in place; common fine roots; many very fine pores; strong effervescence with hydrogen peroxide; many black specks; slightly acid; abrupt, smooth boundary. (7 to 9 inches thick)

B22—19 to 36 inches, dusky-red (2.5YR 3/2) silty clay loam; reddish brown (5YR 4/4) when dry; moderate, very fine, subangular blocky structure; hard, friable, sticky, and plastic; few fine roots; many very fine and fine pores; strong effervescence with hydrogen peroxide; common black specks; neutral; abrupt, wavy boundary. (15 to 19 inches thick)

C—36 inches, variegated hard saprolite.

The depth to saprolite is 32 to 42 inches. In places the A horizon has a weak, platy structure. The hue of the A horizon ranges from 5YR to 7.5YR.

Included in mapping are shallow soils in drainageways.

Permeability is moderate, runoff is medium, and the erosion hazard is moderate. The available water capacity is about 1.5 inches per foot of soil. Roots can penetrate to a depth of 3 feet or more.

This soil is used for pasture. (Capability subclass VIs, nonirrigated; pasture group 2)

Mahukona silty clay loam, 3 to 12 percent slopes (MHC).—This soil is similar to Mahukona very stony silty clay loam, 6 to 12 percent slopes, except that it is nonstony. It is used for irrigated sugarcane and pasture. (Capability subclass IIIe, irrigated, and IIIe, nonirrigated; sugarcane group 1; pasture group 2)

Maile Series

The Maile series consists of well-drained silt loams that formed in volcanic ash. These are nearly level to moderately steep soils on uplands. They are at an elevation ranging from 2,500 to 4,000 feet and receive from 60 to 90 inches of rainfall annually. Their mean annual soil temperature is between 57° and 60° F. The natural vegetation consists of ohia, tree fern, alapaio fern, kikuyugrass, and white clover. These soils and Honokaa, Kahua, Kikoni, Palapalai, Puu Oo, and Umikoa soils are in the same general area.

Maile soils are used for pasture and woodland.

Maile silt loam, 6 to 20 percent slopes (MLD).—This soil is at intermediate elevations on the windward side of

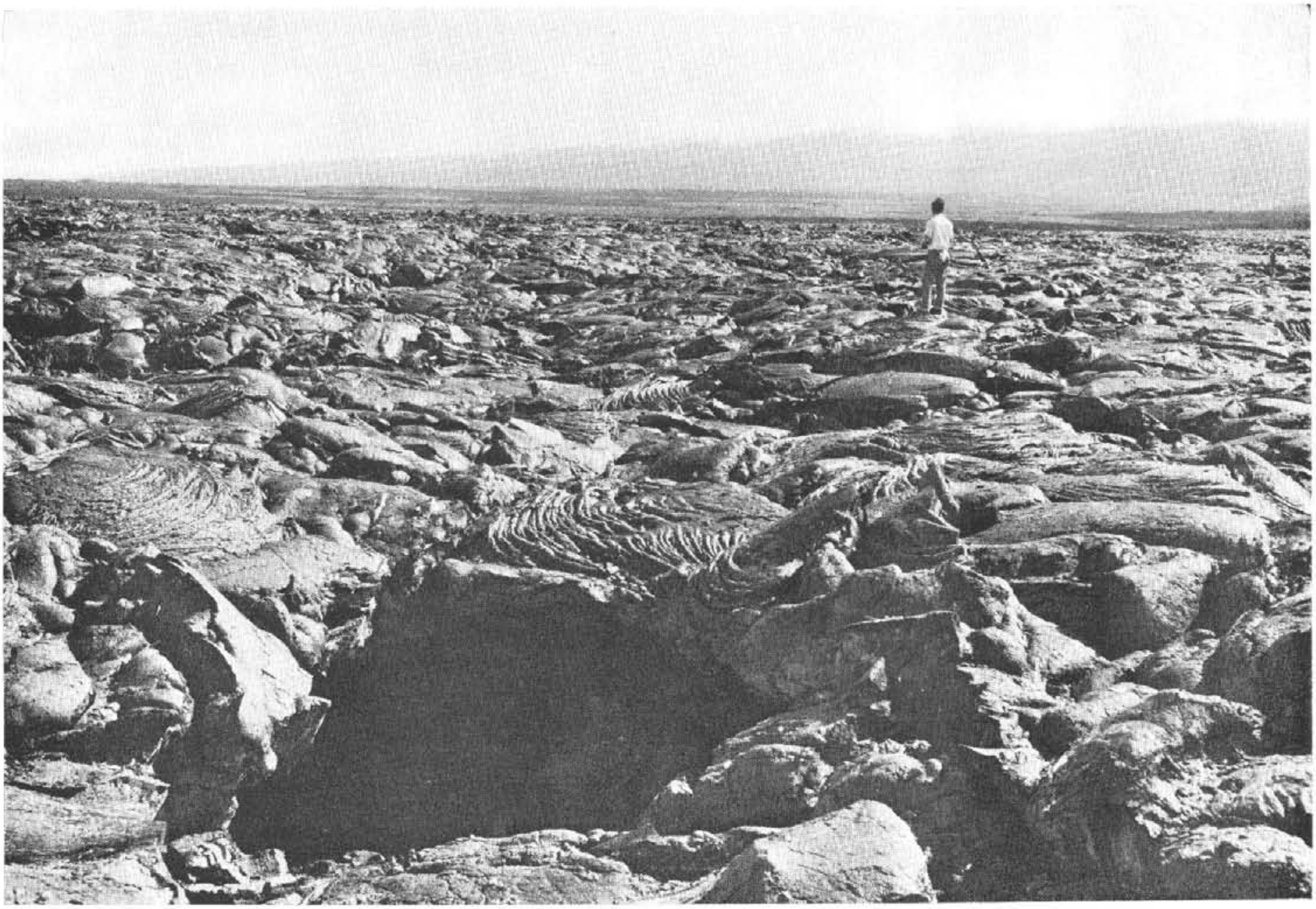


Figure 8.—**Pahoehoe lava flow of the year 1935 in the saddle between Mauna Loa and Mauna Kea.**

Mauna Kea. It has a dominant slope of about 15 percent.

A representative profile has a surface layer of dark reddish-brown to very dark brown silt loam about 14 inches thick. The subsoil is about 46 inches thick. It consists of dark yellowish-brown and very dark brown silty clay loam. The subsoil dehydrates irreversibly into fine sand-size aggregates. The profile grades from medium acid in the surface layer to slightly acid and neutral in the subsoil.

Representative profile, Umikoa Quadrangle, lat. 19°59′00″ N. and long. 155°32′32″ W.:

A11—0 to 2 inches, dark reddish-brown (5YR 2/2) silt loam; black (2.5YR 2/1) when dry; moderate, fine, subangular blocky structure; hard, friable, nonsticky, and slightly plastic; many roots; many fine pores; medium acid; abrupt, smooth boundary. (2 to 3 inches thick)

A12—2 to 4 inches, dark reddish-brown (5YR 2/2) cindery sandy loam; dark brown (10YR 3/3) when dry; moderate, fine, subangular blocky structure; hard, friable, nonsticky, and nonplastic; many roots; common, fine, black cinders and charcoal; medium acid; abrupt, smooth boundary. (2 to 4 inches thick)

A13—4 to 14 inches, very dark brown (10YR 2/2) silty clay loam; dark brown (10YR 3/3) when dry; strong, fine, subangular blocky structure; extremely hard, friable, slightly sticky, plastic, and weakly smeary; many roots; many fine pores; slightly acid; clear, wavy boundary. (8 to 12 inches thick)

B21—14 to 17 inches, dark yellowish-brown (10YR 3/4) silty clay loam; dark brown (7.5YR 3/3) when dry; weak, coarse, prismatic structure that breaks to moderate, fine, subangular blocky structure; very hard, friable, slightly sticky, plastic, and weakly smeary; many roots; many fine pores; slightly acid; clear, smooth boundary. (3 to 5 inches thick)

B22—17 to 20 inches, dark-brown (10YR 3/3) silty clay loam; very dark brown (10YR 2/2) when dry; weak, coarse, prismatic structure that breaks to moderate, fine, subangular blocky structure; very hard, friable, sticky, plastic, and weakly smeary; common roots; many fine pores; slightly acid; clear, smooth boundary. (3 to 5 inches thick)

B23—20 to 24 inches, dark yellowish-brown (10YR 3/4) silty clay loam; very dark brown (10YR 2/2) when dry; weak, coarse, prismatic structure that breaks to moderate, fine, subangular blocky structure; very hard, friable, sticky, plastic, and weakly smeary; few roots; slightly acid; clear, smooth boundary. (3 to 5 inches thick)

IIC—24 to 29 inches, dark-brown (10YR 3/3) silty clay loam; very dark brown (10YR 2/2) when dry; massive; hard, firm, slightly sticky, slightly plastic, and weakly smeary; tuff band; few roots; many fine pores; slightly acid; abrupt, smooth boundary. (3 to 7 inches thick)

IIB24b—29 to 36 inches, dark-brown (7.5YR 3/4) silty clay loam; very dark brown (10YR 2/2) when dry; weak, medium and fine, subangular blocky structure; very hard, friable, sticky, plastic, and moderately smeary; common patchy glaze on peds; few roots; many fine pores; neutral; abrupt, smooth boundary. (3 to 7 inches thick)

IIIB25b—36 to 48 inches, very dark brown (10YR 2/2) silty clay loam; very dark brown (10YR 2/2) when dry; weak, coarse and medium, prismatic structure that breaks to moderate, medium and fine, subangular blocky structure; very hard, friable, sticky, plastic, and moderately smeary; common, patchy, gelatinlike coatings on peds; tuff band about 2 inches thick; few roots; many fine pores; neutral; abrupt, smooth boundary. (10 to 12 inches thick)

IIIB26b—48 to 60 inches, very dark brown (10YR 2/2) silty clay loam; very dark grayish brown (10YR 3/2) when dry; weak, medium, subangular blocky structure; friable, sticky, plastic, and moderately smeary; few roots; many fine pores; neutral.

The A horizon has a chroma and value of 2 or 3 when moist. The B horizon has a hue of 5YR to 10YR and weak to strong, subangular blocky structure. Thin bands of hard ash occur erratically throughout the solum. The B horizon dehydrates irreversibly into dark-brown or black, very hard aggregates the size of sand and silt.

Included with this soil in mapping are small, steep drainageways and gullies.

Permeability is moderately rapid, runoff is slow, and the erosion hazard is slight. Roots can penetrate to a depth of 5 feet or more.

This soil is used for pasture and woodland. (Capability subclass IVe, nonirrigated; pasture group 11; woodland group 8)

Maile silt loam, 0 to 3 percent slopes (MaA).—This soil is similar to Maile silt loam, 6 to 20 percent slopes, except that it is nearly level. Runoff is very slow, and the erosion hazard is none to slight. This soil is used for truck crops and pasture. (Capability class I, nonirrigated; pasture group 11; woodland group 8)

Malama Series

The Malama series consists of well-drained, thin, extremely stony organic soils over Aa lava. These soils are undulating to rolling. They are on mountains at an elevation ranging from near sea level to 1,000 feet, and receive from 60 to 90 inches of rainfall annually. Their mean annual soil temperature is between 72° and 74° F. The natural vegetation consists of guava, waiwe, mango, hala, noni apple, and ohia. These soils and Keei, Opihikao, Puna, and Punaluu soils are in the same general area.

Malama soils are used for woodland, pasture, and orchards.

Malama extremely stony muck, 3 to 15 percent slopes (rMAD).—This soil overlies relatively young Aa lava flows on the windward side of Kilauea Crater.

In a representative profile the surface layer is very dark brown extremely stony muck about 3 inches thick. It is underlain by fragmental Aa lava. This soil is strongly acid.

Representative profile, Kalapana Quadrangle, lat. 19°28′05″ N. and long. 154°51′15″ W.:

O2—3 inches to 0, very dark brown (7.5YR 2/2) extremely stony muck; moderate, medium and fine, subangular blocky structure; friable, slightly sticky, slightly plastic, and weakly smeary; many roots; many fine pores; Aa lava fragments the size of cobbles and stones make up 40 to 80 percent of the soil mass; strongly acid; abrupt, smooth boundary. (2 to 6 inches thick)

IIC—0 to 10 inches, fragmented Aa lava; little soil material in voids.

The depth to fragmental Aa lava ranges from 2 to 8 inches. The hue of the O2 horizon ranges from 7.5YR to 10YR.

Included in mapping are small areas of Opihikao soils.

Permeability is rapid, runoff is very slow, and the erosion hazard is slight. Roots can extend to a depth of 24 inches into cracks of the lava.

This soil is used for woodland, pasture, and orchards. (Capability subclass VIIs, nonirrigated; pasture group 7; woodland group 13)

Manahaa Series

The Manahaa series consists of well-drained silt loams that formed in volcanic ash. These are gently sloping to moderately steep soils on uplands at an elevation ranging from 3,500 to 5,000 feet. They receive from 50 to 80 inches of rainfall annually, most of which falls during the summer months. Their mean annual soil temperature is between 56° and 59° F. The natural vegetation consists of ohia, kikuyugrass, rattail, and yellow foxtail. These soils and Hanipoe, Honaunau, Kealakekua, and Puukala soils are in the same general area.

Manahaa soils are used for pasture and woodland.

Manahaa silt loam, 6 to 20 percent slopes (MMD).—This soil occurs at intermediate elevations on the leeward side of Mauna Loa and Hualalai. The dominant slope is 10 percent.

In a representative profile the surface layer is dusky-red silt loam about 6 inches thick. The subsoil is dark reddish-brown silt loam about 19 inches thick. It is underlain by pahoehoe lava bedrock. This soil dehydrates irreversibly into fine sand-size aggregates. The profile is slightly acid throughout. The surface is extremely stony in places.

Representative profile, Puu Lehua Quadrangle, lat. 19°32′45″ N. and long. 155°52′13″ W.:

A1—0 to 6 inches, dusky-red (2.5YR 3/2) silt loam; moderate, medium and fine, granular structure; slightly hard, friable, slightly sticky, and plastic; many roots; many fine pores; slightly acid; abrupt, smooth boundary. (5 to 7 inches thick)

B21—6 to 10 inches, dark reddish-brown (5YR 3/2) silt loam; weak, medium and coarse, subangular blocky structure; soft, friable, nonsticky, slightly plastic, and weakly smeary; many roots; many very fine pores; common bits of charcoal; few small pockets of black (5YR 2/1) material; slightly acid; abrupt, smooth boundary. (4 to 5 inches thick)

B22—10 to 15 inches, dark reddish-brown (2.5YR 3/4) silt loam; weak, medium and fine, subangular blocky structure; hard, friable, nonsticky, slightly plastic, and weakly smeary; common roots; many very fine pores; nearly continuous, gelatinlike coatings on ped surfaces; slightly acid; abrupt, smooth boundary. (4 to 6 inches thick)

B23—15 to 25 inches, dark reddish-brown (5YR 3/3) silt loam; moderate, medium, subangular blocky structure; hard, friable, slightly sticky, plastic, and weakly smeary; common roots; many fine and very fine pores; nearly continuous, gelatinlike coatings on peds; slightly acid; abrupt, wavy boundary. (8 to 15 inches thick)

IIR—25 inches, pahoehoe lava; roots matted on surface of lava.

The depth to bedrock ranges from 20 to 33 inches. In some places stones are on the surface and in the profile. The A horizon ranges from 2.5YR to 7.5YR in hue and from strong to moderate in structure. The B horizon ranges from weak to moderate in structure. In some areas the pockets of black or dark reddish-brown material are absent in the B horizon. This horizon is weakly to moderately smeary and dehydrates irreversibly into very hard, dark-brown or black aggregates the size of sand and silt.

Included with this soil in mapping are small areas of stony soils and soils that are less than 20 inches deep over pahoehoe lava.

Permeability is moderately rapid, runoff is slow, and the erosion hazard is slight. Roots can penetrate to the pahoehoe lava bedrock.

This soil is used for pasture and woodland. (Capability subclass IVe, nonirrigated; pasture group 11; woodland group 8)

Manahaa extremely stony silt loam, 6 to 20 percent slopes (MND).—This soil is similar to Manahaa silt loam, 6 to 20 percent slopes, except that stones cover 3 to 15 percent of the surface. It is used for pasture and woodland. (Capability subclass VIIs, nonirrigated; pasture group 11; woodland group 8)

Manu Series

The Manu series consists of well-drained silt loams that formed in volcanic ash, cinders, and pumice. These soils are nearly level to gently sloping. They are on uplands at an elevation ranging from 3,000 to 4,000 feet and receive from 80 to 120 inches of rainfall annually. Their mean annual soil temperature is between 58° and 62° F. The natural vegetation consists of ohia, tree fern, amaumau fern, and rattail. These soils and Heake, Kilauea, Kona, Puaulu, and Puhimau soils are in the same general area.

Manu soils are used mostly for woodland. Small areas are used for pasture and truck crops.

Manu silt loam, 2 to 6 percent slopes (rMUB).—This soil is at intermediate elevations on the windward side of Mauna Loa in the Volcano area.

In a representative profile the surface layer is very dark brown silt loam about 3 inches thick over about 5 inches of very dark grayish-brown fine sandy loam. It is underlain by stratified layers of very dark grayish-brown coarse sand, fine sandy loam, and loamy fine sand and dark yellowish-brown pumice. Hard pahoehoe lava bedrock is at a depth of about 36 inches. The profile grades from medium acid in the surface layer to neutral in the lower part of the subsoil.

Representative profile, Kilauea Crater Quadrangle, lat. 19°25′40″ N. and long. 155°15′05″ W.:

A11—0 to 3 inches, very dark brown (10YR 2/2) silt loam; very dark gray (10YR 3/1) when dry; weak, very fine and fine, granular structure; slightly hard, very friable, nonsticky, and slightly plastic; many very fine and fine pores; many roots; roots matted in first inch of this horizon; common hard basalt fragments 2 to 6 millimeters in size; medium acid; abrupt, wavy boundary. (3 to 5 inches thick)

A12—3 to 8 inches, very dark grayish-brown (10YR 3/2) fine sandy loam; grayish brown (2.5Y 5/2) when dry; massive; slightly hard, friable, nonsticky, and nonplastic; many very fine and fine pores; common roots; hard basalt fragments 2 to 10 millimeters in size comprise about 10 percent of horizon; medium acid; abrupt, wavy boundary. (4 to 6 inches thick)

IIC1—8 to 12 inches, very dark grayish-brown (10YR 3/2) coarse sand; light brownish gray (2.5Y 6/2) when dry; massive; slightly hard, friable, nonsticky, and nonplastic; many interstitial pores; common roots; hard basalt fragments from ¼ to ½ inch in size comprise about 10 percent of horizon; slightly acid; abrupt, wavy boundary. (4 to 6 inches thick)

IIIC2—12 to 16 inches, very dark grayish-brown (10YR 3/2) fine sandy loam; grayish brown (2.5Y 5/2) when dry; massive; slightly hard, friable, nonsticky, and nonplastic; many very fine and fine pores; common roots; slightly acid; abrupt, smooth boundary. (2 to 5 inches thick)

IIIC3—16 to 19 inches, very dark grayish-brown (10YR 3/2) loamy fine sand; light olive brown (2.5Y 5/4) when dry; massive; hard, firm, nonsticky, and nonplastic; many fine interstitial pores; few roots; slightly acid; clear, wavy boundary. (2 to 4 inches thick)

IVC4—19 to 22 inches, dark-gray (10YR 4/1) gravelly coarse loamy sand; grayish brown (2.5Y 5/2) when dry; massive; slightly hard, friable, nonsticky, and nonplastic; pockets of dark-gray, sticky and plastic silty clay loam; many interstitial pores; very few roots; hard basalt fragments 2 to 5 millimeters in size comprise about 25 percent of horizon; slightly acid; abrupt, smooth boundary. (2 to 5 inches thick)

VC5—22 to 36 inches, dark yellowish-brown (10YR 3/4) glassy pumice; dark gray (10YR 4/1) when dry; massive; soft, friable, nonsticky, and nonplastic; few roots; neutral; abrupt, smooth boundary. (10 to 16 inches thick)

VIR—36 inches, hard pahoehoe basalt lava.

The depth to pahoehoe lava bedrock ranges from 27 to 47 inches. The A11 horizon is 3 to 5 inches thick and ranges from 7.5YR to 10YR in hue.

Included in mapping are small areas of Puhimau soils.

Permeability is rapid, runoff is slow, and the erosion hazard is slight. Roots can penetrate to the pahoehoe lava bedrock.

Most of this soil is in native forest. A small acreage is used for truck crops and pasture. (Capability subclass IIe, nonirrigated; pasture group 9; woodland group 7)

Mawae Series

The Mawae series consists of well-drained, thin organic soils over fragmental Aa lava. These soils are undulating to rolling. They are on mountains at an elevation ranging from 3,500 to 7,000 feet and receive from 50 to 80 inches of rainfall annually. Their mean annual soil temperature is between 53° and 55° F. The natural vegetation consists of ohia, tree fern, amaumau fern, ieie vine, and mamaki. These soils and Kekake and Kiloa soils are in the same general area.

Mawae soils are used for woodland and watershed.

Mawae extremely stony muck, 6 to 20 percent slopes (rMWD).—This undulating to rolling soil is on Mauna Loa and Hualalai.

In a representative profile the surface layer is black extremely stony muck about 5 inches thick. It is underlain by fragmental Aa lava. The surface layer is medium acid.

Representative profile, Honaunau Quadrangle, lat. 19°29′05″ N. and long. 155°51′57″ W.:

O2—5 inches to 0, black (5YR 2/1) extremely stony muck; weak, fine and very fine, granular structure; very

friable, slightly sticky, slightly plastic, and moderately smeary; many roots; many very fine pores; 50 to 80 percent Aa lava fragments from gravel to stone size; medium acid; clear, irregular boundary. (2 to 10 inches thick)

IIC—0 to 10 inches, Aa lava; very little soil material from above horizon in crevices and cracks.

The thickness of the O2 horizon ranges from 2 to 10 inches. The hue is 5YR to 10YR.

Permeability is rapid, runoff is slow, and the erosion hazard is slight. Roots are generally matted in the surface layer, although a few extend into the crevices of the underlying lava.

Most of this soil is in native forest and is used for watershed. Some areas are cleared for pasture. (Capability subclass VIIs, nonirrigated; pasture group 12; woodland group 14)

Mixed Alluvial Land

Mixed alluvial land (MT) is a miscellaneous land type consisting of recent stream deposition that varies widely in texture. This land is in the Waipio, Pololu, and Waimanu Valleys. It is on bottoms at the mouth of the valleys and is subject to frequent flooding. The surface is littered with stones and boulders.

Mixed alluvial land is at an elevation ranging from sea level to 500 feet and receives from 50 to 100 inches of rainfall annually. The mean annual soil temperature is about 73° F. The vegetation consists of hilograss, guava, honohonograss, and monkey pod.

Included with this land in mapping are areas of talus material along the base of the steep valley sides. It consists of rock debris and soil material.

Mixed alluvial land is used for grazing and for wildlife habitat. (Capability subclass VIw, nonirrigated; pasture group 7; woodland group 5)

Moaula Series

The Moaula series consists of well-drained silty clay loams that formed in volcanic ash. These soils are gently sloping to steep. They are on uplands at an elevation ranging from 1,300 to 1,900 feet, and they receive from 60 to 90 inches of rainfall annually. Their mean annual soil temperature is between 68° and 70° F. The natural vegetation consists of Christmas berry, guava, joee, and kikuyugrass. These soils and Alapai and Naalehu soils are in the same general area.

Moaula soils are used for sugarcane.

Moaula silty clay loam, 0 to 10 percent slopes (MoC).—This soil is at low elevations on the windward side of Mauna Loa.

In a representative profile the surface layer is very dark brown silty clay loam about 9 inches thick. The subsoil is dark reddish-brown silty clay loam about 65 inches thick. Bedrock is at a depth of more than 5 feet. The subsoil is weakly smeary and dehydrates irreversibly into fine sand-size aggregates. The profile is very strongly acid in the surface layer and slightly acid to neutral in the subsoil.

Representative profile, Punaluu Quadrangle, lat. 19°08′10″ N. and long. 155°33′55″ W.:

Ap—0 to 9 inches, very dark brown (10YR 2/2) silty clay loam; dark yellowish brown (10YR 4/6) when dry; strong, medium and fine, subangular blocky structure; slightly hard, friable, slightly sticky, and plastic; many roots; common very fine and fine roots; few, firm and very firm, dark-red (2.5YR 3/6) nodules of volcanic ash 1 to 5 millimeters in diameter; very strongly acid; abrupt, wavy boundary. (6 to 12 inches thick)

B21—9 to 17 inches, dark reddish-brown (5YR 3/4) silty clay loam; moderate, medium, subangular blocky structure; friable, sticky, plastic, and weakly smeary; many roots; many very fine pores; patchy, thin, gelatinlike coatings on ped surfaces; few, firm, dark-red (2.5YR 3/6) nodules of volcanic ash about 7 millimeters in diameter; slightly acid; clear, wavy boundary. (6 to 10 inches thick)

B22—17 to 23 inches, dark reddish-brown (5YR 3/3) silty clay loam; moderate, fine and very fine, subangular blocky structure; friable, slightly sticky, plastic, and weakly smeary; many roots; many very fine and fine pores; a few, dark-red, gravel-size fragments of volcanic ash; thin, gelatinlike coatings on ped surfaces; slightly acid; abrupt, wavy boundary. (4 to 8 inches thick)

B23—23 to 31 inches, dark reddish-brown (5YR 3/4) silty clay loam; moderate, fine and very fine, subangular blocky structure; friable, slightly sticky, plastic, and weakly smeary; few roots; many very fine and fine pores; common, firm and very firm, dark reddish-brown (2.5YR 3/4) fragments of volcanic ash ¼ inch to 2 inches in diameter; slightly acid; clear, wavy boundary. (5 to 10 inches thick)

B24—31 to 40 inches, dark reddish-brown (5YR 3/3) silty clay loam; moderate, fine and very fine, subangular blocky structure; friable, slightly sticky, plastic, and weakly smeary; few roots; many very fine and fine pores; few, firm and very firm, dark reddish-brown, gravel-size fragments of volcanic ash; neutral; clear, wavy boundary. (7 to 11 inches thick)

B25—40 to 48 inches, dark reddish-brown (5YR 3/4) silty clay loam; moderate, fine and very fine, subangular blocky structure; friable, sticky, plastic, and weakly smeary; few roots; many very fine and fine pores; common patches of gelatinlike coatings on ped surfaces; common, firm and very firm, dark reddish-brown, gravel-size fragments of volcanic ash; neutral; abrupt, wavy boundary. (5 to 10 inches thick)

B26—48 to 54 inches, dark reddish-brown (5YR 3/4) silty clay loam; common, fine, distinct, yellowish-brown (10YR 5/6) mottles; moderate, fine and very fine, subangular blocky structure; friable, slightly sticky, plastic, and weakly smeary; few roots; many very fine and fine pores; common, firm and very firm, dark reddish-brown, gravel-size fragments of volcanic ash; common patches of gelatinlike coatings on ped surfaces; neutral; abrupt, wavy boundary. (4 to 8 inches thick)

B27—54 to 65 inches, dark reddish-brown (5YR 3/4) silty clay loam; few, fine, distinct, yellowish-brown (10YR 5/6) mottles; moderate, fine and very fine, subangular blocky structure; friable, slightly sticky, plastic, and moderately smeary; few roots; common patches of gelatinlike coatings on ped surfaces; neutral; abrupt, smooth boundary. (9 to 12 inches thick)

B28—65 to 74 inches, yellowish-red (5YR 4/6) and dark-brown (7.5YR 3/4) silty clay loam; common, fine, distinct, dark reddish-brown (2.5YR 3/3) mottles; weak, fine and very fine, subangular blocky structure; friable, sticky, plastic, and moderately smeary; no roots; common very fine and fine pores; few patches of gelatinlike coatings on ped surfaces; neutral.

The depth to bedrock is more than 60 inches. The A horizon has a value and chroma of 2 or 3 when moist.

Included in mapping are small areas that are a mixture of stones and soil material deposited as mud flows

or landslides. These included areas are quite variable and generally have a stony profile.

Permeability is moderately rapid, runoff is slow, and the erosion hazard is slight. Roots can penetrate to a depth of 5 feet or more.

This soil is used for sugarcane. (Capability subclass IIIe, nonirrigated; sugarcane group 3; pasture group 7; woodland group 5)

Moaula silty clay loam, 10 to 20 percent slopes (MoD).—This soil is similar to Moaula silty clay loam, 0 to 10 percent slopes, except that it is moderately steep. Runoff is medium, and the erosion hazard is moderate.

Included in mapping are small areas that are a mixture of stones and soil material deposited as mud flows or landslides.

This soil is used for sugarcane. (Capability subclass IVe, nonirrigated; sugarcane group 3; pasture group 7; woodland group 5)

Moaula silty clay loam, 20 to 35 percent slopes (MoE).—This soil is similar to Moaula silty clay loam, 0 to 10 percent slopes, except that the slopes are steep. Runoff is medium, and the erosion hazard is severe.

Included in mapping are small areas that have very steep slopes.

This soil is used for sugarcane. (Capability subclass VIe, nonirrigated; sugarcane group 3; pasture group 7; woodland group 5)

Naalehu Series

The Naalehu series consists of well-drained silty clay loams that formed in volcanic ash. These soils are nearly level to steep. They are on uplands at an elevation ranging from 750 to 1,800 feet, and they receive from 35 to 60 inches of rainfall annually. Their mean annual soil temperature is between 72° and 75° F. The natural vegetation consists of Christmas berry, bermudagrass, guava, and kaimi clover. These soils and Kaimu, Kamaoa, Kapapala, Moaula, and Pakini soils are in the same general area.

Naalehu soils are used mostly for sugarcane. Small areas are used for pasture.

Naalehu silty clay loam, 10 to 20 percent slopes (NaD).—This soil is on the low leeward side of Mauna Loa.

In a representative profile the surface layer is very dark brown silty clay loam about 20 inches thick (fig. 9). The upper part of the subsoil is dark-brown silty clay loam about 11 inches thick. The lower part is 22 inches thick or more and consists of dark reddish-brown silt loam. The substratum also is dark reddish-brown silt loam. The surface layer is slightly acid, and the subsoil is neutral.

Representative profile, Naalehu Quadrangle, lat. 19°04′13″ N. and long. 155°35′18″ W.:

Ap—0 to 20 inches, very dark brown (10YR 2/2) silty clay loam; dark grayish brown (10YR 4/2) when dry; moderate, medium and fine, granular structure; hard, friable, sticky, and plastic; many roots matted on top of lower horizon; many fine pores; slightly acid; abrupt, smooth boundary. (16 to 24 inches thick)

B21—20 to 31 inches, dark-brown (10YR 3/3) silty clay loam; dark brown (7.5YR 4/4) when dry; weak, coarse, prismatic structure; hard, firm, sticky, plastic, and weakly smeary; upper 6 inches compact; few roots mostly along old root channels; many charcoal fragments; many worm casts in old channels; neutral; clear, smooth boundary. (8 to 14 inches thick)

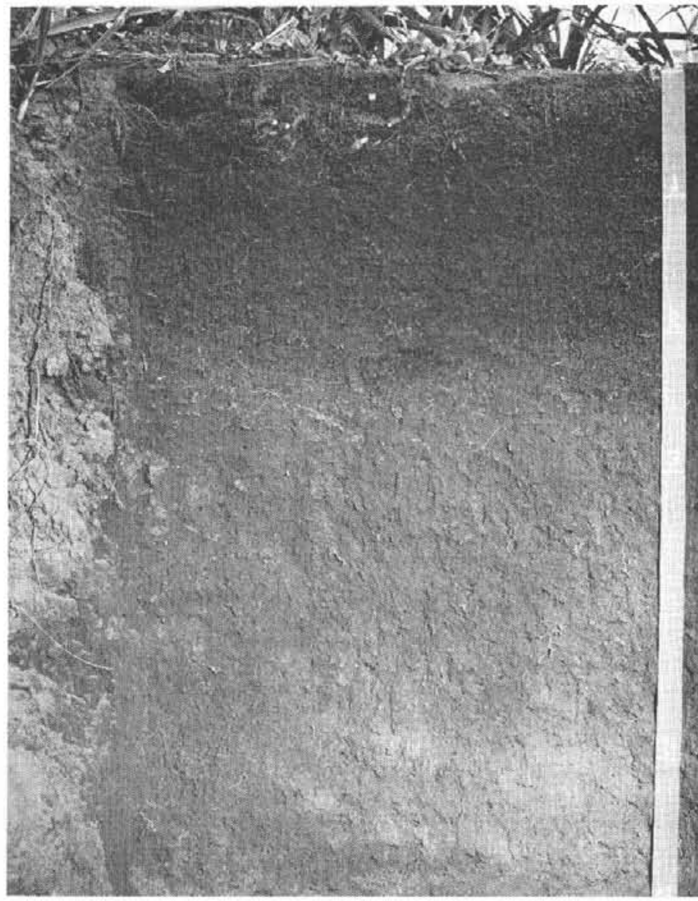


Figure 9.—**Profile of Naalehu silty clay loam, showing thick A horizon.**

IIB22—31 to 36 inches, dark reddish-brown (5YR 3/2) silt loam; dark reddish brown (5YR 3/4) when dry; massive; hard, friable, slightly sticky, slightly plastic, and weakly smeary; few roots; many very fine pores; tuff band nearly continuous; neutral; clear, wavy boundary. (5 to 9 inches thick)

IIIB23—36 to 53 inches, dark reddish-brown (5YR 3/3) silt loam; dark red (2.5YR 3/6) when dry; weak, coarse, prismatic structure; slightly hard, very friable, nonsticky, plastic, and weakly smeary; few roots; very porous; neutral; clear, wavy boundary. (14 to 18 inches thick)

IVC—53 to 65 inches, dark reddish-brown (5YR 3/3) silt loam; dark reddish brown (2.5YR 3/4) when dry; massive; very friable, nonsticky, slightly plastic, and weakly smeary; few roots; many fine pores; neutral.

The depth to pahoehoe or Aa lava is more than 40 inches. The A horizon has a chroma of 1 to 3 when moist. The B horizon has a chroma of 2 to 4 and a value of 3 to 4 when moist.

Included in mapping are small, moderately eroded areas that have a lighter colored surface layer than is typical. They are generally on the steepest slopes.

Permeability is moderately rapid, runoff is medium, and the erosion hazard is moderate. Roots can penetrate to a depth of 40 inches or more.

This soil is used mostly for sugarcane. Small areas are used for pasture. (Capability subclass IVe, nonirri-

gated; sugarcane group 2; pasture group 5; woodland group 2)

Naalehu silty clay loam, 0 to 10 percent slopes (NaC).—This soil is similar to Naalehu silty clay loam, 10 to 20 percent slopes, except that the slopes are less steep. Runoff is slow, and the erosion hazard is slight. Included in mapping are small areas that have steep slopes.

This soil is used mostly for sugarcane. Small areas are used for pasture. (Capability subclass IIIe, nonirrigated; sugarcane group 2; pasture group 5; woodland group 2)

Naalehu silty clay loam, 20 to 35 percent slopes (NaE).—This soil is similar to Naalehu silty clay loam, 10 to 20 percent slopes, except that the slopes are steeper. Runoff is medium, and the erosion hazard is severe.

This soil is used for sugarcane and pasture. (Capability subclass VIe, nonirrigated; sugarcane group 2; pasture group 5; woodland group 2)

Naalehu very rocky silty clay loam, 6 to 20 percent slopes (NhD).—This soil is shallower than is typical for the Naalehu series. It is only 20 to 36 inches deep to bedrock, and rock outcrops make up 5 to 15 percent of the surface. Included in mapping are small areas of soils that are less than 15 inches deep over bedrock. These inclusions occupy less than 10 percent of this unit. Runoff is slow to medium, and the erosion hazard is slight to moderate.

This soil is used for pasture. (Capability subclass VIs, nonirrigated; pasture group 5; woodland group 2)

Niulii Series

The Niulii series consists of well-drained silty clay loams that formed in volcanic ash. These soils are gently sloping to steep. They are on uplands at an elevation ranging from 600 to 2,000 feet. They receive from 80 to 100 inches of rainfall annually, and their mean annual soil temperature is between 69° and 72° F. The natural vegetation consists of hilograss, guava, ohia, and kikuyugrass. These soils and Ainakea, Kehena, and Palapalai soils are in the same general area.

Niulii soils are used for sugarcane and macadamia nuts.

Niulii silty clay loam, 6 to 12 percent slopes (NIC).—This soil is low on the windward side of the Kohala Mountains. The dominant slope is about 10 percent.

In a representative profile the soil is dark-brown silty clay loam to a depth of 30 inches. It is underlain by pahoehoe lava. This soil dehydrates irreversibly into fine sand-size aggregates. It grades from very strongly acid in the upper part to medium acid in the lower part.

Representative profile, Hawi Quadrangle, lat. 20°11′42″ N. and long. 155°47′35″ W.:

Ap1—0 to 8 inches, dark-brown (10YR 3/3) silty clay loam; strong, medium and fine, subangular blocky structure; friable, slightly sticky, and slightly plastic; many roots; many very fine pores; very strongly acid; abrupt, smooth boundary. (8 to 10 inches thick)

Ap2—8 to 12 inches, dark-brown (7.5YR 3/4) silty clay loam; strong, very fine and fine, subangular blocky structure; friable, sticky, plastic, and weakly smeary; many roots; many very fine and fine pores; many gelatinlike coatings on ped surfaces; common lava fragments from gravel to stone size; very strongly acid; clear, smooth boundary. (3 to 6 inches thick)

B21—12 to 19 inches, dark-brown (7.5YR 3/3) silty clay loam; moderate, very fine and fine, subangular blocky structure; friable, sticky, plastic, and weakly smeary; common roots; many very fine and fine pores; many gelatinlike coatings on ped surfaces; common lava fragments from gravel to stone size; strongly acid; abrupt, smooth boundary. (6 to 10 inches thick)

B22—19 to 30 inches, dark-brown (10YR 3/3) silty clay loam; moderate, very fine and fine, subangular blocky structure; friable, sticky, plastic, and weakly smeary; few roots; many very fine and fine pores; many lava fragments from gravel to stone size; medium acid; abrupt, wavy boundary. (8 to 12 inches thick)

IIR—30 inches, hard pahoehoe lava.

The depth to bedrock ranges from 20 to 40 inches. The value and chroma are 3 or 4 in the B horizon. This horizon is weakly smeary to moderately smeary.

Permeability is moderately rapid, runoff is slow, and the erosion hazard is slight. Roots can penetrate to bedrock.

This soil is used for sugarcane and macadamia nuts. (Capability subclass IIIe, nonirrigated; sugarcane group 3; pasture group 7; woodland group 5)

Niulii silty clay loam, 12 to 20 percent slopes (NID).—This soil is similar to Niulii silty clay loam, 6 to 12 percent slopes, except that the slopes are steeper. Runoff is medium, and the erosion hazard is moderate.

This soil is used for sugarcane and macadamia nuts. (Capability subclass IVe, nonirrigated; sugarcane group 3; pasture group 7; woodland group 5)

Niulii silty clay loam, 20 to 35 percent slopes (NIE).—This soil is similar to Niulii silty clay loam, 6 to 12 percent slopes, except that the slopes are steeper. Runoff is medium, and the erosion hazard is severe. Included in mapping on the steepest slopes are areas where most of the surface layer has been removed by erosion.

This soil is used for sugarcane and macadamia nuts. (Capability subclass VIe, nonirrigated; sugarcane group 3; pasture group 7; woodland group 5)

Ohia Series

The Ohia series consists of well-drained silty clay loams that formed in volcanic ash. These are nearly level to steep soils on uplands. They are at an elevation ranging from 900 to 2,000 feet and receive from 125 to 200 inches of rainfall annually. Their mean annual soil temperature is between 65° and 68° F. The natural vegetation consists of ohia, tree fern, glenwoodgrass, and hamakua pamakani. These soils and Akaka, Hilea, Olaa, and Panaewa soils are in the same general area.

Ohia soils are used mostly for sugarcane, pasture, and woodland. Small areas are used for truck crops.

Ohia silty clay loam, 0 to 10 percent slopes (OHC).—This soil is low on the windward side of Mauna Loa near Glenwood and Kurtistown.

In a representative profile the surface layer is dark-brown and very dark brown silty clay loam about 9 inches thick. The subsoil is dark reddish-brown and dark-brown silty clay loan. It is underlain by unweathered pahoehoe lava at a depth of about 62 inches.

This soil dehydrates irreversibly into fine gravel-size aggregates. It is extremely acid in the surface layer and strongly acid to medium acid in the subsoil. The surface is extremely stony in places.

Representative profile, Puu Makaala Quadrangle, lat. 19°31′56″ N. and long. 155°08′04″ W.:

Ap1—0 to 6 inches, dark-brown (7.5YR 3/2) silty clay loam; moderate, fine and medium, subangular blocky structure; friable, slightly sticky, plastic, and weakly smeary; roots matted; many medium and fine pores; extremely acid; clear, wavy boundary. (4 to 8 inches thick)

Ap2—6 to 9 inches, very dark brown (7.5YR 2/2) silty clay loam; common, fine, distinct mottles of dark reddish brown (5YR 3/4); moderate, fine and very fine, subangular blocky structure; friable, slightly sticky, plastic, and weakly smeary; many roots; many very fine and fine pores; extremely acid; abrupt, wavy boundary. (1 to 5 inches thick)

B1—9 to 13 inches, dark reddish-brown (5YR 3/3) silty clay loam; weak, fine, subangular blocky structure; friable, slightly sticky, plastic, and strongly smeary; many roots; many very fine to coarse pores; smooth, gelatinlike coatings on ped surfaces; strongly acid; abrupt, wavy boundary. (3 to 7 inches thick)

B21—13 to 23 inches, dark reddish-brown (5YR 3/3) silty clay loam; moderate, fine and very fine, subangular blocky structure; friable, sticky, plastic, and strongly smeary; common roots; common very fine pores; smooth, gelatinlike coatings on ped surfaces; medium acid; abrupt, wavy boundary. (6 to 12 inches thick)

B22—23 to 32 inches, dark reddish-brown (5YR 3/4) silty clay loam; moderate, fine, and very fine, subangular blocky structure; friable, sticky, plastic, and strongly smeary; common roots; common fine and very fine pores; smooth, gelatinlike coatings on ped surfaces; medium acid; clear, wavy boundary. (7 to 12 inches thick)

B23—32 to 62 inches, dark-brown (7.5YR 3/2) silty clay loam; moderate, fine and very fine, subangular blocky structure; firm, slightly sticky, plastic, and strongly smeary; few roots; common very fine pores; smooth, gelatinlike coatings on ped surfaces; common firm and very firm fragments of volcanic ash; medium acid; abrupt, smooth boundary. (28 to 35 inches thick)

IIR—62 inches, relatively unweathered pahoehoe lava.

The hue of the A horizon ranges from 10YR to 7.5YR. In places the Ap horizon lacks mottles. Thin bands of highly weathered, weakly cemented volcanic ash occur at a depth of 20 to 50 inches.

Permeability is rapid, runoff is slow, and the erosion hazard is slight. Roots can penetrate to a depth of 4 feet or more.

This soil is used mostly for sugarcane, pasture, and woodland. Small areas are used for truck crops and orchards. (Capability subclass IIIe, nonirrigated; sugarcane group 4; pasture group 9; woodland group 7)

Ohia extremely stony silty clay loam, 0 to 20 percent slopes (OSD).—This soil is shallower than is typical of the series. It is only 20 to 36 inches deep over fragmental Aa lava. The dominant slope is about 10 percent. Stones cover from 3 to 15 percent of the surface. Runoff is slow to medium, and the erosion hazard is slight to moderate. Included in mapping are small areas of soils that are less than 20 inches deep over fragmental Aa lava.

This soil is used for sugarcane, woodland, and pasture. (Capability subclass VIIs, nonirrigated; pasture group 9; woodland group 7)

Olaa Series

The Olaa series consists of well-drained silty clay loams that formed in volcanic ash. These soils are nearly level to moderately steep. They are on uplands at an elevation ranging from 200 to 1,000 feet and receive from 100 to 175 inches of rainfall annually. Their mean annual soil temperature is between 71° and 73° F. The natural vegetation consists of ohia, tree fern, guava, and hilograss. These soils and Hilea, Hilo, Keaukaha, Ohia, Panaewa, and Papai soils are in the same general area.

Olaa soils are used for sugarcane.

Olaa extremely stony silty clay loam, 0 to 20 percent slopes (OlD).—This soil is undulating to rolling and has a dominant slope of about 12 percent.

In a representative profile the surface layer is very dark brown extremely stony silty clay loam about 16 inches thick. The subsoil is dark-brown extremely stony silty clay loam about 9 inches thick. It is underlain by Aa lava. This soil dehydrates irreversibly into gravel-size aggregates. It has a medium acid surface layer and a slightly acid subsoil. In places the surface layer is nonstony.

Representative profile, Mountain View Quadrangle, lat. 19°36′53″ N. and long. 155°02′55″ W.:

Ap1—0 to 8 inches, very dark brown (10YR 2/2) extremely stony silty clay loam; strong, medium and fine, subangular blocky structure; friable, slightly sticky, and plastic; many roots; many fine pores; stones, cobbles, and gravel occupy 20 to 30 percent by volume; medium acid; clear, wavy boundary. (5 to 10 inches thick)

Ap2—8 to 16 inches, very dark brown (10YR 2/2) very stony silty clay loam; strong, fine, subangular blocky structure; friable, slightly sticky, plastic, and weakly smeary; many roots; many fine and very fine pores; stones and cobbles occupy 30 to 40 percent by volume; slightly acid; abrupt, smooth boundary. (4 to 11 inches thick)

B2—16 to 25 inches, dark-brown (7.5YR 3/3) extremely stony silty clay loam; moderate, fine, subangular blocky structure; friable, slightly sticky, plastic, and moderately smeary; common roots; many very fine and fine pores; stones and cobbles occupy 50 to 80 percent by volume; slightly acid; clear, wavy boundary. (4 to 12 inches thick)

IIR—25 inches, fragmental Aa lava.

Stones and cobbles occupy 10 to 50 percent of the soil by volume. The depth to Aa lava ranges from 20 to 30 inches. The A1 horizon ranges from 7.5YR to 10YR in hue and feels gritty in places because of the fine basalt fragments and the irreversibly hardened material. The B horizon has weak to moderate structure and is moderately to strongly smeary.

Permeability is rapid, runoff is slow, and the erosion hazard is slight. Roots penetrate to the fragmental Aa lava.

This soil is used for sugarcane. (Capability subclass VIIs, nonirrigated; pasture group 9; woodland group 7)

Olaa silty clay loam, 0 to 10 percent slopes (OaC).—This soil is similar to Olaa extremely stony silty clay loam, 0 to 20 percent slopes, except that the surface layer is nonstony, and the slope is generally less than 10 percent. Stones and cobbles occupy 10 to 20 percent of the soil by volume.

This soil is used for sugarcane. (Capability subclass IIIe, nonirrigated; sugarcane group 2; pasture group 9; woodland group 7)

Ookala Series

The Ookala series consists of well-drained silty clay loams that formed in volcanic ash. These soils are gently sloping to steep. They occupy coastal areas on Mauna Kea at an elevation ranging from near sea level to 1,000 feet, and they receive from 90 to 120 inches of rainfall annually. Their mean annual soil temperature is between 72° and 74° F. The natural vegetation consists of hilograss, guava, and californiagrass. These soils and Hilo, Honokaa, Kukaiau, and Paauhau soils are in the same general area.

Ookala soils are used for sugarcane.

Ookala silty clay loam, 12 to 20 percent slopes (OoD).—This soil occupies coastal areas on the windward side of Mauna Kea.

In a representative profile the surface layer is dark reddish-brown silty clay loam about 12 inches thick. The subsoil is dark-brown to dark yellowish-brown silty clay loam about 43 inches thick. This is underlain by very dark grayish-brown, partly weathered Aa lava fragments. This soil dehydrates irreversibly into fine sand-size aggregates. It has a very strongly acid surface layer and a slightly acid to medium acid subsoil.

Representative profile, Kukaiau Quadrangle, lat. 20°01′14″ N. and long. 155°18′08″ W.:

Ap—0 to 12 inches, dark reddish-brown (5YR 3/3) and dark-brown (10YR 3/3) silty clay loam; moderate and strong, medium and fine, subangular blocky structure; friable, sticky, and plastic; many roots; many very fine and fine pores; very strongly acid; abrupt, wavy boundary. (10 to 12 inches thick)

B1—12 to 17 inches, dark yellowish-brown (10YR 3/4) silty clay loam; moderate, medium and fine, subangular blocky structure; friable, sticky, and plastic; many roots; many very fine and fine pores; common, patchy, gelatinlike coatings on ped surfaces; few firm nodules of volcanic ash about one-eighth to one-quarter inch in size; slightly acid; abrupt, wavy boundary. (2 to 8 inches thick)

B21—17 to 27 inches, dark-brown (7.5YR 3/4) silty clay loam; strong, fine and very fine, subangular blocky structure; firm, sticky, plastic, and weakly smeary; many roots; many very fine and fine pores; common, patchy, gelatinlike coatings on ped surfaces; common firm nodules of volcanic ash about one-quarter inch in size; horizon is compact in place; slightly acid; abrupt, wavy boundary. (4 to 14 inches thick)

B22—27 to 37 inches, dark yellowish-brown (10YR 3/4) silty clay loam; strong, medium and fine, subangular blocky structure; firm, sticky, plastic, and weakly smeary; common roots; many very fine and fine pores, and few medium and coarse pores; common, patchy, gelatinlike coatings on ped surfaces; few, small, hard rock fragments; horizon is compact in place; medium acid; abrupt, smooth boundary. (8 to 18 inches thick)

B23—37 to 50 inches, dark yellowish-brown (10YR 3/4) silty clay loam; strong, medium and fine, subangular blocky structure; firm, sticky, plastic, and weakly smeary; common roots; many fine and very fine pores; medium acid; abrupt, wavy boundary. (10 to 15 inches thick)

B24—50 to 55 inches, dark-brown (10YR 4/3) silty clay loam; strong, fine and very fine, subangular blocky structure; friable, sticky, plastic, and weakly smeary; few roots; many very fine and fine pores; common, patchy, gelatinous coatings on ped surfaces; medium acid; abrupt, wavy boundary. (3 to 8 inches thick)

IIC—55 inches, very dark grayish-brown, partly weathered Aa lava fragments.

This soil is more than 40 inches deep. The Ap horizon ranges from 5YR to 10YR in hue.

Permeability is moderately rapid, runoff is medium, and the erosion hazard is moderate. Roots penetrate to a depth of 4 or 5 feet.

This soil is used for sugarcane. (Capability subclass IVe, nonirrigated; sugarcane group 2; pasture group 7; woodland group 5)

Ookala silty clay loam, 6 to 12 percent slopes (OoC).—This soil is similar to Ookala silty clay loam, 12 to 20 percent slopes, except that it is not so steep. Runoff is slow, and the erosion hazard is slight.

This soil is used for sugarcane. (Capability subclass IIIe, nonirrigated; sugarcane group 2; pasture group 7; woodland group 5)

Ookala silty clay loam, 20 to 35 percent slopes (OoE).—This soil is similar to Ookala silty clay loam, 12 to 20 percent slopes, except that the slopes are steeper. Runoff is rapid, and the erosion hazard is severe.

This soil is used for sugarcane. (Capability subclass VIe, nonirrigated; sugarcane group 2; pasture group 7; woodland group 5)

Opihikao Series

The Opihikao series consists of well-drained, thin organic soils over pahoehoe lava bedrock. These soils are gently sloping to moderately steep. They are on uplands at an elevation ranging from near sea level to 1,000 feet and receive from 60 to 90 inches of rainfall annually. Their mean annual soil temperature is between 72° and 73° F. The natural vegetation consists of guava, waiwe, and ohia. These soils and Keei, Kona, Malama, Papai, and Puna soils are in the same general area.

Opihikao soils are in native forest or are used for pasture.

Opihikao extremely rocky muck, 3 to 25 percent slopes (rOPE).—This soil is in the Puna district. Rock outcrops occupy 30 to 50 percent of the area.

In a representative profile the surface layer is very dark brown muck about 3 inches thick. It is underlain by pahoehoe lava bedrock. The muck is strongly acid.

Representative profile, Kalapana Quadrangle, lat. 19°28′08″ N. and long. 154°50′20″ W.:

O2—3 inches to 0, very dark brown (7.5YR 2/2) muck; moderate, medium and fine, subangular blocky structure; friable, slightly sticky, slightly plastic, and weakly smeary; roots matted; many fine pores; 40 to 60 percent pahoehoe outcrop; strongly acid; abrupt, smooth boundary. (2 to 4 inches thick)

IIR—0 to 10 inches, pahoehoe lava.

The depth to pahoehoe lava bedrock is 2 to 5 inches. The hue of the O2 horizon ranges from 7.5YR to 10YR.

The muck is rapidly permeable. The lava is very slowly permeable, but water moves rapidly through the cracks. Runoff is slow, and the erosion hazard is slight. Roots are matted over the pahoehoe lava, but they can penetrate the cracks to a depth of 2 feet.

This soil is in native forest or is used for pasture. (Capability subclass VIIs, nonirrigated; pasture group 7)

Paauhau Series

The Paauhau series consists of well-drained silty clay loams that formed in volcanic ash. These soils are gently sloping to steep. They are in coastal areas on Mauna Kea at an elevation ranging from near sea level to 1,000 feet and receive from 60 to 80 inches of rainfall annually. Their mean annual soil temperature is between 72° and 74° F. The natural vegetation consists of bermudagrass, hilograss, kaimi clover, and carpetgrass. These soils and Kukaiau and Ookala soils are in the same general area.

Paauhau soils are used mostly for sugarcane. Small acreages are used for truck crops and pasture.

Paauhau silty clay loam, 12 to 20 percent slopes (PaD).—This soil is low on the windward side of Mauna Kea. The dominant slope is 15 percent.

In a representative profile the surface layer is very dark grayish-brown silty clay loam about 10 inches thick. The subsoil is dark-brown silty clay loam about 34 inches thick. The substratum is weathering, basic igneous rock. This soil dehydrates irreversibly into fine sand-size aggregates. It is strongly acid in the surface layer and medium acid to slightly acid in the subsoil.

Representative profile, Honokaa Quadrangle, lat. 20°04′57″ N. and long. 155°26′31″ W.:

Ap—0 to 10 inches, very dark grayish-brown (10YR 3/2) silty clay loam; dark brown (10YR 4/3) when dry; moderate, medium and fine, granular structure; hard, friable, sticky, and plastic; many roots; many, very fine and fine, interstitial pores; common basalt fragments ranging from 1 to 4 inches in size; strongly acid; abrupt, wavy boundary. (9 to 12 inches thick)

B1—10 to 18 inches, dark-brown (7.5YR 3/3) silty clay loam; weak, fine, subangular blocky structure; friable, slightly sticky, plastic, and weakly smeary; many roots; many, very fine and fine, tubular pores; common basalt fragments ranging from 1 to 4 inches in size; medium acid; abrupt, wavy boundary. (2 to 8 inches thick)

B21—18 to 26 inches, dark-brown (7.5YR 3/3) silty clay loam; moderate, fine and very fine, subangular blocky structure; friable, slightly sticky, plastic, and weakly smeary; common roots; many, fine, tubular pores, and common, medium, tubular pores; common basalt fragments ranging from 1 to 4 inches in size; few pockets of material that has strong, medium, subangular blocky structure; patchy, shiny coatings on ped surfaces; medium acid; abrupt, wavy boundary. (8 to 20 inches thick)

B22—26 to 44 inches, dark-brown (7.5YR 3/3) very stony silty clay loam; moderate, medium and fine, subangular blocky structure; friable, slightly sticky, plastic, and nonsmeary; few roots; many, fine, tubular pores; basalt fragments ranging from pebbles to stones occupy from 35 to 50 percent of horizon; slightly acid; clear, wavy boundary. (15 to 25 inches thick)

IIC—44 to 60 inches, material consisting of about 85 percent basalt fragments ranging from gravel to stone size and 15 percent soil similar to that in above horizon.

The thickness of the solum ranges from 36 inches to more than 60 inches. The B horizon ranges from 2 to 4 in chroma and value and from silty clay loam to silt loam in texture.

Included with this soil in mapping are small areas of soils, near the Paauhau and Hamakua sugar mills, that have a black surface layer.

Permeability is moderately rapid, runoff is medium, and the erosion hazard is moderate. Roots can penetrate to a depth of 3 feet or more. The available water capacity is 1.8 inches per foot of soil.

This soil is used mostly for sugarcane. Small acreages are used for pasture and truck crops. (Capability subclass IVe, irrigated, and IVe, nonirrigated; sugarcane group 1; pasture group 7; woodland group 5)

Paauhau silty clay loam, 6 to 12 percent slopes (PaC).—This soil is similar to Paahau silty clay loam, 12 to 20 percent slopes, except that it is not so steep. Runoff is slow, and the erosion hazard is slight.

This soil is used mostly for sugarcane. Small acreages are used for truck crops and pasture. (Capability subclass IIIe, irrigated, and IIIe, nonirrigated; sugarcane group 1; pasture group 7; woodland group 5)

Paauhau silty clay loam, 20 to 35 percent slopes (PaE).—This soil is similar to Paauhau silty clay loam, 12 to 20 percent slopes, except that it is steeper. Runoff is rapid, and the erosion hazard is severe.

This soil is used mostly for sugarcane. Small acreages are used for pasture. (Capability subclass VIe, irrigated, and VIe, nonirrigated; sugarcane group 1; pasture group 7; woodland group 5)

Pakini Series

The Pakini series consists of well-drained very fine sandy loams that formed in volcanic ash. These soils are nearly level to gently sloping. They are on Mauna Loa at an elevation ranging from near sea level to 1,000 feet and receive from 20 to 40 inches of rainfall annually. Their mean annual soil temperature is between 72° and 75° F. The natural vegetation consists of Japanese tea, sandbur, cocklebur, lantana, bermudagrass, and piligrass. These soils and Kaalualu, Kaimu, Kamaoa, Naalehu, and Punaluu soils are in the same general area.

Pakini soils are used for pasture.

Pakini very fine sandy loam, 2 to 6 percent slopes (PKB).—This soil is in the South Point area. The dominant slope is 5 percent.

In a representative profile the surface layer is very dark brown and dark-brown very fine sandy loam about 16 inches thick. The subsoil is dark-brown and brown loam about 29 inches thick. It is underlain by very fine sandy loam that is high in calcium carbonate. The surface layer is neutral, and the subsoil is mildly alkaline.

Representative profile, Ka Lae Quadrangle, lat. 18°56′30″ N. and long. 155°41′38″ W.:

Ap—0 to 3 inches, very dark brown (10YR 2/2) very fine sandy loam; dark grayish brown (10YR 4/2) when dry; weak, medium, platy structure; slightly hard, very friable, nonsticky, and nonplastic; many roots; common rock fragments 2 to 5 millimeters in diameter; neutral; abrupt, smooth boundary. (2 to 4 inches thick)

A1—3 to 8 inches, dark-brown (7.5YR 3/3) very fine sandy loam; dark yellowish brown (10YR 4/4) when dry; weak, medium and coarse, prismatic structure; slightly hard, friable, nonsticky, and nonplastic; many roots along faces of prisms; common rock fragments 2 to 5 millimeters in diameter; neutral; clear, wavy boundary. (4 to 5 inches thick)

A3—8 to 16 inches, dark-brown (7.5YR 4/4) very fine sandy loam; yellowish brown (10YR 5/4) when dry; weak, coarse, prismatic structure; slightly hard,

friable, nonsticky, and nonplastic; common roots; common rock fragments 2 to 5 millimeters in size; neutral; clear, wavy boundary. (7 to 10 inches thick)

B21—16 to 29 inches, dark-brown (7.5YR 4/4) loam; strong brown (7.5YR 5/6) when dry; weak, coarse, prismatic structure; slightly hard, friable, slightly sticky, and slightly plastic; few fine roots; common olivine sand particles; mildly alkaline; gradual, wavy boundary. (10 to 18 inches thick)

B22—29 to 45 inches, brown (7.5YR 5/4) loam; yellowish brown (10YR 5/6) when dry; weak, coarse, prismatic structure; slightly hard, friable, slightly sticky, and slightly plastic; few roots; few fine rock fragments; few vertical streaks of calcium carbonate on prism faces and in pores; mildly alkaline; gradual, wavy boundary. (12 to 20 inches thick)

Cca—45 to 60 inches, brown (7.5YR 5/4) very fine sandy loam; yellowish brown (10YR 5/6) when dry; massive; slightly hard, friable, nonsticky, and nonplastic; calcium carbonate increases with depth; matrix effervesces weakly with hydrochloric acid; few pockets effervesce violently with hydrochloric acid; mildly alkaline.

The depth to Aa or pahoehoe lava is more than 40 inches. The Ap horizon has a value of 4 or 5 and a chroma of 2 to 4 when dry and a value of 2 to 4 when moist. The B horizon has a value of 3 to 5 when moist.

Included in mapping are small areas that are high in content of olivine sand and small areas that have a slope greater than 6 percent. Also included are about 50 acres of black, very sticky, plastic soils. These black soils are self-mulching. They adjoin Pakini soils in depressions.

Permeability is rapid, runoff is slow, and the hazard of soil blowing is moderate. Roots can penetrate to a depth of 3 to 5 feet.

This soil is used for pasture. (Capability subclass VIe, nonirrigated; pasture group 2)

Palapalai Series

The Palapalai series consists of well-drained silt loams that formed in volcanic ash. These soils are gently sloping to moderately sloping. They are on uplands at an elevation ranging from 3,000 to 3,500 feet and receive from 40 to 90 inches of rainfall annually. Their mean annual soil temperature is between 62° and 65° F. The natural vegetation consists of kikuyugrass, rattail, bermudagrass, and white clover. These soils and Kehena, Maile, Niulii, and Waimea soils are in the same general area.

Palapalai soils are used for pasture.

Palapalai silt loam, 6 to 12 percent slopes (PLC).—This soil is at intermediate elevations on the leeward side of the Kohala Mountains.

A representative profile consists of dark-brown silt loam to a depth of 60 inches or more. This soil grades from slightly acid in the upper part of the surface layer to neutral in the subsoil.

Representative profile, Kawaihae Quadrangle, lat. 20°06′47″ N. and long. 155°46′48″ W.:

A1—0 to 6 inches, dark-brown (7.5YR 3/2) silt loam; strong, medium and fine, subangular blocky structure; very hard, friable, slightly sticky, and plastic; many roots; roots matted in upper 2 inches of horizon; many medium and fine pores; slightly acid; abrupt, smooth boundary. (5 to 7 inches thick)

A3—6 to 16 inches, dark-brown (7.5YR 3/3) silt loam; weak, fine, subangular blocky structure; soft, friable, slightly sticky, and plastic; many roots; many fine and very fine pores; many sugarlike coatings on ped faces; neutral; clear, smooth boundary. (9 to 10 inches thick)

B21—16 to 31 inches, dark-brown (7.5YR 3/3) silt loam; weak, coarse, prismatic structure that breaks to moderate, medium, subangular blocky structure; soft, friable, slightly sticky, plastic, and weakly smeary; many roots; many medium and fine pores; many sugarlike coatings on ped faces; neutral; clear, smooth boundary. (13 to 16 inches thick)

B22—31 to 48 inches, dark-brown (7.5YR 3/3) silt loam; weak, coarse, prismatic structure; soft, friable, slightly sticky, plastic, and weakly smeary; common roots; many medium and fine pores; many sugarlike coatings on ped faces; neutral; clear, smooth boundary. (16 to 20 inches thick)

B23—48 to 60 inches, dark-brown (10YR 3/3) silt loam; weak, coarse, prismatic structure; hard, friable, slightly sticky, plastic, and weakly smeary; few roots; many medium and fine pores; many sugarlike coatings; few cobble-size fragments of basalt; slightly acid.

The texture of the B horizon ranges from silt loam to silty clay loam.

Included with this soil in mapping are some short slopes that are steeper than 12 percent.

Permeability is moderately rapid, runoff is slow, and the erosion hazard is slight. Roots can penetrate to a depth of 4 or 5 feet.

This soil is used for pasture. (Capability subclass IIIe, nonirrigated; pasture group 12; woodland group 9)

Palapalai silty clay loam, 6 to 12 percent slopes (PMC).—This soil is similar to Palapalai silt loam, 6 to 12 percent slopes, except that it has a silty clay loam surface layer. It is used for pasture. (Capability subclass IIIe, nonirrigated; pasture group 12; woodland group 9)

Panaewa Series

The Panaewa series consists of shallow, moderately well drained silty clay loams that formed in volcanic ash. These soils are nearly level to gently sloping. They are on uplands at an elevation ranging from 300 to 1,000 feet and receive from 100 to 175 inches of rainfall annually. Their mean annual soil temperature is between 72° and 74° F. The natural vegetation consists of ohia, tree fern, hilograss, californiagrass, and guava. These soils and Hilea, Keaukaha, Ohia, Olaa, and Papai soils are in the same general area.

Panaewa soils are used for sugarcane, pasture, and woodland.

Panaewa very rocky silty clay loam, 0 to 10 percent slopes (PeC).—This soil is near Keaau. Rock outcrops occupy 10 to 25 percent of the surface.

In a representative profile the surface layer is very dark brown silty clay loam about 12 inches thick. The subsoil is about 4 inches thick and consists of dark-brown very cobbly silty clay loam, mottled with yellowish red. It is underlain by pahoehoe lava bedrock. The subsoil dehydrates irreversibly into fine gravel-size aggregates. The surface layer is medium acid, and the subsoil is strongly acid.

Representative profile, Hilo Quadrangle, lat. 19°37′54″ N. and long. 155°03′06″ W.:

Ap—0 to 12 inches, very dark brown (10YR 2/2) silty clay loam; moderate, medium and fine, subangular blocky

structure; friable, slightly sticky, plastic, and weakly smeary; many roots; many fine and very fine pores; 10 to 20 percent gravel-size fragments of basalt; medium acid; abrupt, smooth boundary. (11 to 13 inches thick)

B2—12 to 16 inches, dark-brown (7.5YR 4/4 and 3/2) very cobbly silty clay loam; common, fine, prominent mottles of yellowish red (5YR 3/6); moderate, fine, subangular blocky structure; friable, slightly sticky, plastic, and moderately smeary; many roots; many fine pores; 40 to 60 percent gravel-size and cobble-size fragments of basalt; strongly acid; abrupt, broken boundary. (4 to 7 inches thick)

IIR—16 inches, pahoehoe lava bedrock.

The depth to pahoehoe lava bedrock ranges from 15 to 20 inches. The soil is always moist. The Ap horizon has a hue of 5YR to 10YR and a value and chroma of 2 or 3.

Permeability is rapid, runoff is slow, and the erosion hazard is slight. Roots can penetrate to bedrock.

This soil is used for sugarcane, pasture, and woodland. (Capability subclass VIs, nonirrigated; sugarcane group 2; pasture group 9; woodland group 12)

Papai Series

The Papai series consists of well-drained, thin, extremely stony organic soils over fragmental Aa lava. These soils are gently sloping to moderately steep. They are on uplands at an elevation ranging from near sea level to 1,000 feet and receive from 90 inches to more than 150 inches of rainfall annually. Their soil temperature is between 72° and 74° F. The natural vegetation consists of ohia, tree fern, uluhe fern, and guava. These soils and Keaukaha, Kiloa, Olaa, Opihikao, and Panaewa soils are in the same general area.

Papai soils are used mostly for woodland. Small areas are used for pasture, orchards, and truck crops.

Papai extremely stony muck, 3 to 25 percent slopes (rPAE).—This soil is low on the windward side of Mauna Kea.

In a representative profile the surface layer is very dark brown extremely stony muck about 8 inches thick. It is underlain by fragmental Aa lava. This soil is slightly acid.

Representative profile, Hilo Quadrangle, lat. 19°39′05″ N. and long. 155°03′55″ W.:

O2—8 inches to 0, very brown (10YR 2/2) extremely stony muck; moderate, medium and fine, subangular blocky structure; friable, slightly sticky, slightly plastic, and moderately smeary; many roots; many fine pores; slightly acid; abrupt, wavy boundary. (3 to 12 inches thick)

IIC—0 to 10 inches, fragmental Aa lava; a small amount of material from above horizon in voids and cracks.

The depth to fragmental Aa lava ranges from 3 to 12 inches. The hue of the surface layer ranges from 7.5YR to 10YR.

Permeability is rapid, runoff is slow, and the erosion hazard is slight. (Capability subclass VIIs, nonirrigated; pasture group 9; woodland group 13)

Piihonua Series

The Piihonua series consists of well-drained silty clay loams. These soils formed in a series of layers of volcanic ash and have a banded appearance. They are gently sloping to moderately steep soils on uplands. They are at an elevation ranging from 4,500 to 6,500 feet and receive from 90 to 150 inches of rainfall annually. Their mean annual soil temperature is between 55° and 58° F. The natural vegetation consists of ohia, koa, alapaio fern, sweet vernal, and kikuyugrass. These soils and Akaka, Lalaau, Puaulu, and Puu Oo soils are in the same general area.

Piihonua soils are used for pasture and woodland.

Piihonua silty clay loam, 6 to 20 percent slopes (PND).—This soil is high on the windward side of Mauna Kea.

In a representative profile the surface layer is very dark brown silty clay loam about 6 inches thick. The subsoil is dark-brown to dark-red silty clay loam about 44 inches thick. A weakly cemented layer of volcanic ash occurs at a depth of 17 to 25 inches. The profile is very strongly acid to extremely acid. The surface is extremely stony in places. This soil dehydrates irreversibly into fine gravel-size aggregates.

Representative profile, Pua Akala Quadrangle, lat. 19°-48′14″ N. and long. 155°19′13″ W.:

A1—0 to 6 inches, very dark brown (10YR 2/2) silty clay loam; moderate, fine, granular structure; friable, slightly sticky, plastic, and weakly smeary; many roots; many, very fine and fine, interstitial pores; few worm holes and casts; very strongly acid; abrupt, smooth boundary. (3 to 6 inches thick)

B2—6 to 17 inches, dark-brown (7.5YR 3/2) silty clay loam; moderate, medium and fine, subangular blocky structure; friable, slightly sticky, plastic, and strongly smeary; common roots; many fine and very fine pores; thick, gelatinlike coatings on ped surfaces; extremely acid; clear, smooth boundary. (8 to 12 inches thick)

IIC—17 to 25 inches, very dark grayish-brown (10YR 3/2), weakly cemented volcanic ash that breaks down to sandy clay loam; massive; very firm, slightly sticky, plastic, and strongly smeary; few roots; many very fine pores; nearly continuous, thick, gelatinlike coatings on cleavage planes; very strongly acid; abrupt, wavy boundary. (6 to 10 inches thick)

IIIB21b—25 to 32 inches, very dark grayish-brown (10YR 3/2) silty clay loam; moderate, fine, subangular blocky structure; friable, sticky, plastic, and strongly smeary; common roots; many very fine pores; thick, gelatinlike coatings on ped surfaces; a broken layer of dark reddish-brown (5YR 3/4) material, 1 to 3 inches thick, occurs in this horizon; very strongly acid; abrupt, smooth boundary. (6 to 11 inches thick)

IIIB22b—32 to 37 inches, dark-red (2.5YR 3/6) silty clay loam; moderate, medium and fine, subangular blocky structure; friable, sticky, plastic, and strongly smeary; common roots; many very fine pores; thick, gelatinlike coatings on ped faces; few firm peds; very strongly acid; abrupt, smooth boundary. (4 to 6 inches thick)

IIIB23b—37 to 41 inches, dark-brown (10YR 3/3) silty clay loam; moderate, medium and fine, subangular blocky structure; friable, sticky, plastic, and strongly smeary; common roots; many fine pores; thick, gelatinlike coating on ped faces; very strongly acid; abrupt, smooth boundary. (4 to 6 inches thick)

IIIB24b—41 to 50 inches, dark reddish-brown (5YR 3/3) silty clay loam; moderate, fine, subangular blocky structure; friable, sticky, plastic, and smeary; common roots; many fine pores; thick, gelatinlike coatings on peds; strongly acid.

The A horizon ranges from 5YR to 10YR in hue when moist and has a value and chroma of 2 or less.

Permeability is rapid, runoff is slow, and the erosion hazard is slight. Roots can penetrate to a depth of 40 inches or more.

This soil is used for pasture and woodland. (Capability subclass IVe, nonirrigated; pasture group 8; woodland group 6)

Piihonua extremely stony silty clay loam, 6 to 20 percent slopes (POD).—This soil is similar to Piihonua silty clay loam, 6 to 20 percent slopes, except that stones cover 3 to 15 percent of the surface.

This soil is used for pasture and woodland. (Capability subclass VIIs, nonirrigated; pasture group 8; woodland group 6)

Puaulu Series

The Puaulu series consists of well-drained silt loams that formed in volcanic ash. These soils are nearly level to moderately sloping. They are on uplands at an elevation ranging from 3,800 to 4,500 feet and receive from 90 to 120 inches of rainfall annually. Their mean annual soil temperature is between 55° and 58° F. The natural vegetation consists of ohia, tree fern, glenwoodgrass, kikuyugrass, and amaumau fern. These soils and Haeke, Manu, Piihonua, and Puhimau soils are in the same general area.

Puaulu soils are used mostly for woodland, pasture, and truck crops. Small acreages are used for orchards.

Puaulu silt loam, 0 to 10 percent slopes (PPC).—This soil is at intermediate elevations on the windward side of Kilauea.

In a representative profile the surface layer is dark reddish-brown silt loam about 7 inches thick. Below this are alternating layers of volcanic ash, pumice, and cinders. The surface layer is very strongly acid. The underlying layers are neutral to medium acid. This soil dehydrates irreversibly into gravel-size aggregates.

Representative profile, Volcano Quadrangle, lat. 19°27′38″ N. and long. 155°14′55″ W.:

A1—0 to 7 inches, dark reddish-brown (5YR 2/2) silt loam; moderate, medium, fine and very fine, subangular blocky structure; friable, slightly sticky, slightly plastic, and moderately smeary; many roots, matted at lower boundary in some places; many very fine pores; very strongly acid; abrupt, smooth boundary. (5 to 8 inches thick)

IIC1—7 to 16 inches, black (10YR 2/1), relatively unweathered volcanic sand; compact in places; massive; firm, nonsticky, and nonplastic; few roots, mostly in cracks; few to common fine pores; neutral; abrupt, smooth boundary. (8 to 10 inches thick)

IIC2—16 to 22 inches, black (10YR 2/1), unweathered volcanic ash with cinders and pumice; few small pockets of dark reddish-brown (5YR 3/3) and dark-brown (7.5YR 3/2) coarse silt loam; massive; friable, slightly sticky, slightly plastic, and weakly smeary; few roots; many fine pores; thin, gelatinlike coatings on ped surfaces; slightly acid; abrupt, smooth boundary. (4 to 7 inches thick)

IIIC3—22 to 28 inches, dark reddish-brown (5YR 3/2) light clay loam; many, very hard, gray, black, and reddish-yellow particles of volcanic ash 1 to 4 millimeters in diameter; moderate, fine, subangular blocky structure; friable, sticky, plastic, and moderately smeary; common roots; common very fine pores; medium acid; abrupt, wavy boundary. (3 to 7 inches thick)

IIIC4—28 to 33 inches, black (5YR 2/1) light silty clay loam; moderate, fine, subangular blocky structure; friable to firm, slightly sticky, plastic, and moderately smeary; common roots; common very fine pores; many, fine, black cinders; few dark reddish-brown particles of pumice; few gray, very hard particles of volcanic ash; smooth, gelatinlike coatings on ped surfaces; medium acid; abrupt, wavy boundary. (3 to 10 inches thick)

IIIC5—33 to 42 inches, variegated very dark brown (10YR 2/2), dark-brown (7.5YR 3/2), reddish-yellow (7.5YR 6/6), dark reddish-brown (5YR 3/3) and black (5YR 2/1) soil material; black material consists of coarse silty clay loam; moderate, fine and very fine, subangular blocky structure; friable, sticky, plastic, and moderately smeary; many, very hard, weakly cemented, gravel-size fragments of volcanic ash; common roots; common very fine pores; medium acid; abrupt, wavy boundary. (7 to 12 inches thick)

IVC6—42 to 47 inches, gray, hard, weakly cemented, gravel-size fragments of volcanic ash; few pockets of black (5YR 2/1) and dark yellowish-brown (10YR 4/4) silt loam; weak, fine and very fine, subangular blocky structure; friable, slightly sticky, slightly plastic, and smeary; common roots; many very fine and fine pores; medium acid; abrupt, smooth boundary. (3 to 6 inches thick)

IVC7—47 to 54 inches, volcanic ash; upper half is relatively unweathered and dark reddish-brown (5YR 2/3); massive; friable to firm; lower half is unweathered and dark-gray (5YR 4/1); massive; firm; few roots; common fine and very fine pores; slightly acid; abrupt, smooth boundary. (6 to 8 inches thick)

IVC8—54 to 63 inches, alternating layers of black (5YR 2/1) and dark-brown (7.5YR 3/2) silt loam and dark-gray (N 4/0), firm volcanic ash; weak, medium and fine, subangular blocky structure; friable, slightly sticky, slightly plastic, and moderately smeary; few roots; common very fine pores; few, hard, gravel-size fragments of basalt; slightly acid; abrupt, smooth boundary. (8 to 10 inches thick)

IVC9—63 to 72 inches, dark-brown (7.5YR 3/2) silt loam; moderate, coarse, subangular blocky structure; firm, slightly sticky, slightly plastic, and moderately smeary; few roots; many very fine pores; few small pockets of very firm weakly cemented, gravel-size fragments of volcanic ash that are dark reddish-brown (2.5YR 2/4) and gray; slightly acid; abrupt, wavy boundary. (7 to 12 inches thick)

This soil is more than 60 inches deep. The C horizon ranges from sand to silty clay loam in texture and is friable to very firm. The layers in the C horizon that are finer than silt loam dehydrate irreversibly into black and dark-brown, gravel-size aggregates that are angular and very hard.

Permeability is rapid, runoff is slow, and the erosion hazard is slight. Roots can penetrate to a depth of 4 feet or more.

This soil is used for woodland, pasture, truck crops, and orchards. (Capability subclass IIIe, nonirrigated; pasture group 8; woodland group 6)

Puhimau Series

The Puhimau series consists of shallow, well-drained silt loams that formed in volcanic ash and pumice over pahoehoe lava bedrock. These soils are nearly level to gently sloping. They are on uplands at an elevation ranging from 3,000 to 4,000 feet and receive from 80 to 125 inches of rainfall annually. Their mean annual soil temperature is between 59° and 60° F. The natural vegetation consists of ohia, tree fern, false staghorn fern, and glenwoodgrass. These soils and Heake, Manu, and Puaulu soils are in the same general area.

Puhimau soils are used mostly for woodland. Small acreages are used for pasture and truck crops.

Puhimau silt loam, 2 to 6 percent slopes (rPHB).—This soil is at intermediate elevations on the windward side of Kilauea.

A representative profile has a surface layer of very dark brown and very dark grayish-brown silt loam and loamy fine sand. This layer is about 5 inches thick. The next layer is about 8 inches thick and consists of very dark grayish-brown and dark-gray sandy loam. It is underlain by pahoehoe lava. This soil dehydrates irreversibly into sand-size aggregates. It is medium acid in the surface layer and slightly acid in the underlying material.

Representative profile, Kilauea Crater Quadrangle, lat. 19°24′05″ N. and long. 155°15′72″ W.:

A11—0 to 3 inches, very dark brown (10YR 2/2) silt loam; dark gray (10YR 4/1) when dry; weak, very fine and fine, granular structure; slightly hard, friable, nonsticky, and slightly plastic; roots matted in the upper 2 inches; many, very fine and fine, interstitial pores; medium acid; abrupt, wavy boundary. (2 to 4 inches thick)

A12—3 to 5 inches, very dark grayish-brown (10YR 3/2) loamy fine sand; grayish brown (2.5Y 5/2) when dry; massive; slightly hard, very friable, nonsticky, and nonplastic; common roots; many, medium and fine, interstitial pores; basalt gravel fragments ranging from 2 to 10 millimeters in size make up about 5 percent of horizon; medium acid; abrupt, smooth boundary. (1 to 3 inches thick)

C1—5 to 9 inches, dark-gray (10YR 4/1) fine sandy loam; dark grayish brown (10YR 4/2) when dry; massive; slightly hard, friable, nonsticky, and nonplastic; common roots; many, very fine and fine, interstitial pores; slightly acid; abrupt, wavy boundary. (3 to 5 inches thick)

C2—9 to 13 inches, very dark grayish-brown (10YR 3/2) sandy loam; dark yellowish brown (10YR 4/4) when dry; massive; slightly hard, friable, nonsticky, and nonplastic; common roots; many, medium and fine, interstitial pores; slightly acid; abrupt, smooth boundary. (2 to 4 inches thick)

IIR—13 inches, hard pahoehoe lava.

The depth to pahoehoe lava ranges from 10 to 16 inches. Rock outcrops are common. The C1 horizon ranges from loamy fine sand to fine sandy loam or sandy loam in texture.

Included with this soil in mapping are small areas of Keei and Kahaluu soils.

Permeability is rapid, runoff is slow, and the erosion hazard is moderate. Roots are matted over the pahoehoe lava bedrock, but they can extend a few feet into cracks and crevices.

This soil is used for woodland, pasture, and truck crops. (Capability subclass IIIs, nonirrigated; pasture group 10; woodland group 11)

Puna Series

The Puna series consists of well-drained, thin, extremely stony organic soils over fragmental Aa lava. These soils are gently sloping to moderately steep. They are on uplands at an elevation ranging from 1,000 to 3,500 feet and receive from 60 to 90 inches of rainfall annually. Their mean annual soil temperature is 63° F. The natural vegetation consists of ohia, guava, Christmas berry, and alapaio fern. These soils and Kona, Malama, and Opihikao soils are in the same general area.

Puna soils are used for woodland, pasture, and orchards.

Puna extremely stony muck, 3 to 25 percent slopes (rPXE).—This soil is at intermediate elevations on Mauna Loa and Hualalai.

In a representative profile the surface layer is very dark brown extremely stony muck about 5 inches thick. It is underlain by fragmental Aa lava. This soil is neutral in reaction.

Representative profile, Pohue Bay Quadrangle, lat. 19°06′45″ N. and long. 155°49′50″ W.:

O2—5 inches to 0, very dark brown (7.5YR 2/2) extremely stony muck; moderate, medium and fine, subangular blocky structure; friable, slightly sticky, slightly plastic, and weakly smeary; abundant roots; many fine pores; neutral; abrupt, smooth boundary. (2 to 6 inches thick)

IIC—0 to 10 inches, Aa lava and a little soil material from above.

The depth to fragmental Aa lava is 2 to 6 inches.

Permeability is rapid, runoff is slow, and the erosion hazard is slight. Roots are matted in the surface layer, but some roots extend to a depth of 20 inches into the cracks in the lava.

This soil is used for woodland, pasture, and orchards. (Capability subclass VIIs, nonirrigated; pasture group 7; woodland group 13)

Punaluu Series

The Punaluu series consists of well-drained, thin organic soils over pahoehoe lava bedrock. These soils are gently sloping to moderately steep. They are on uplands at an elevation ranging from near sea level to 1,000 feet and receive from 60 to 90 inches of rainfall annually. The mean annual soil temperature is between 72° and 74° F. The natural vegetation consists of koa haole, Christmas berry, guineagrass, natal redtop, and sand bur. These soils and Kaalualu, Kaimu, Kainaliu, Malama, Pakini, and Waiaha soils are in the same general area.

Punaluu soils are used for pasture.

Punaluu extremely rocky peat, 6 to 20 percent slopes (rPYD).—This soil is low on the leeward side of Mauna Loa. Rock outcrops occupy 40 to 50 percent of the surface.

In a representative profile the surface layer is black peat about 4 inches thick. It is underlain by pahoehoe lava bedrock. This soil is medium acid.

Representative profile, Punaluu Quadrangle, lat. 19°08′56″ N. and long. 155°30′58″ W.:

O2—4 inches to 0, black (10YR 2/1) peat; weak, very fine, granular structure; very friable, nonsticky, nonplastic, and nonsmeary; many roots; many very fine pores; few pebbles on surface; medium acid; abrupt, wavy boundary. (3 to 8 inches thick)

IIR—0 to 10 inches, hard pahoehoe lava.

The O2 horizon ranges from 3 to 8 inches in thickness and from 5YR to 10YR in hue.

The peat is rapidly permeable. The pahoehoe lava is very slowly permeable, although water moves rapidly through the cracks. Runoff is slow, and the erosion hazard is slight. Roots are matted over the pahoehoe lava.

This soil is used for pasture. (Capability subclass VIIs, nonirrigated; pasture group 3)

Punohu Series

The Punohu series consists of well-drained silt loams that formed in volcanic ash. These soils are moderately sloping to moderately steep. They are on uplands at an elevation ranging from 3,500 to 4,500 feet and receive from 50 to 80 inches of rainfall annually. Their mean annual soil temperature is between 56° and 59° F. The natural vegetation consists of hilograss, rattail, sweet vernal, and mountain dandelion. These soils and Hanipoe and Kikoni soils are in the same general area.

Punohu soils are used for pasture.

Punohu silt loam, 12 to 20 percent slopes (PRD).—This soil is at intermediate elevations on the leeward side of Mauna Kea.

A representative profile has a surface layer of dark-brown silt loam about 5 inches thick. The subsoil is about 62 inches thick and consists of dark-brown, very dark grayish-brown, and dark reddish-brown silt loam and silty clay loam. The subsoil dehydrates irreversibly into fine sand-size aggregates. The substratum is bedrock. This soil is medium acid throughout.

Representative profile, Makahalau Quadrangle, lat. 19°59′22″ N. and long. 155°31′10″ W.:

A1—0 to 5 inches, dark-brown (7.5YR 3/2) silt loam; strong, medium and fine, subangular blocky structure; slightly hard, friable, slightly sticky, and plastic; many roots; many very fine pores; medium acid; abrupt, smooth boundary. (3 to 6 inches thick)

B21—5 to 14 inches, dark-brown (7.5YR 3/3) silt loam; weak, fine and very fine, subangular blocky structure; soft, friable, slightly sticky, slightly plastic, and weakly smeary; many roots; many fine and very fine pores; medium acid; clear, wavy boundary. (8 to 12 inches thick)

B22—14 to 23 inches, dark yellowish-brown (10YR 3/4) silt loam; weak, fine and very fine, subangular blocky structure; soft, friable, slightly sticky, slightly plastic, and weakly smeary; many roots; many very fine pores; few, hard, gravel-size fragments of ash; medium acid; abrupt, smooth boundary. (8 to 10 inches thick)

B23—23 to 36 inches, very dark grayish-brown (10YR 3/2) silty clay loam; moderate, fine, subangular blocky structure; hard, friable, slightly sticky, plastic, and weakly smeary; many roots; many fine and very fine pores; lower 2 inches consists of hard tuff band; medium acid; abrupt, smooth boundary. (10 to 15 inches thick)

IIB24b—36 to 54 inches, very dark grayish-brown (10YR 3/2) silty clay loam; strong, fine and very fine, subangular blocky structure; hard, friable, slightly sticky, plastic, and weakly smeary; common roots; many fine and very fine pores; patchy, gelatinlike coatings on peds; medium acid; abrupt, wavy boundary. (15 to 20 inches thick)

IIB25b—54 to 57 inches, dark reddish-brown (5YR 3/3) silty clay loam; compact ash band; weak, fine, subangular blocky structure; very hard, very firm, slightly sticky, plastic, and weakly smeary; few roots; many very fine pores; medium acid; abrupt, wavy boundary. (3 to 4 inches thick)

IIB26b—57 to 67 inches, very dark grayish-brown (10YR 3/2) silty clay loam; strong, fine and very fine, subangular blocky structure; very hard, friable, slightly sticky, plastic, and weakly smeary; common roots; many fine and very fine pores; patchy, gelatinlike coatings on peds; medium acid.

The depth to bedrock ranges from 3 feet to more than 6 feet. The hue of the solum ranges from 5YR to 10YR.

Permeability is moderately rapid, runoff is medium, and the erosion hazard is moderate. Roots can penetrate to a depth of 3 feet or more.

This soil is used for pasture. (Capability subclass IVe, nonirrigated; pasture group 11; woodland group 8)

Puukala Series

The Puukala series consists of shallow, well-drained silt loams that formed in recent volcanic ash over pahoehoe lava bedrock. These are gently sloping to moderately sloping soils on uplands. They are at an elevation ranging from 3,500 to 6,000 feet and receive from 80 to 100 inches of rainfall annually, mostly during the summer months. The mean annual soil temperature is between 59° and 62° F. The natural vegetation consists of ohia, koa, tree fern, alapaio fern, puu lehua, and carpetgrass. These soils and Kealakekua and Manahaa soils are in the same general area.

Puukala soils are used for woodland and pasture.

Puukala extremely stony silt loam, 6 to 12 percent slopes (PSC).—This soil is at intermediate elevations on the leeward side of Mauna Loa and Hualalai.

In a representative profile the surface layer is very dark brown extremely stony silt loam about 6 inches thick. The subsoil is very dark brown and dark reddish-brown stony silt loam about 12 inches thick. The subsoil dehydrates irreversibly into fine sand-size aggregates. Pahoehoe lava bedrock is at a depth of about 18 inches. This soil is strongly acid in the surface layer and medium acid in the subsoil.

Representative profile, Kailua Quadrangle, lat. 19°43′01″ N. and long. 155°55′16″ W.:

A11—0 to 3 inches, very dark brown (7.5YR 2/2) extremely stony silt loam; very dark gray (10YR 3/1) when dry; moderate, medium and fine, subangular blocky structure; friable, slightly sticky, and slightly plastic; many roots; many very fine pores; about 3 to 5 percent of the surface is covered with stones, and stones make up 10 to 20 percent of the horizon; strongly acid; clear, wavy boundary. (2 to 5 inches thick)

A12—3 to 6 inches, very dark brown (10YR 2/2) stony silt loam; very dark grayish brown (10YR 3/2) when dry; moderate, fine and very fine, subangular blocky structure; friable, slightly sticky, and slightly plastic; many roots; many fine pores; 10 to 20 percent stones; strongly acid; abrupt, wavy boundary. (2 to 5 inches thick)

B21—6 to 14 inches, very dark brown (7.5YR 2/2) stony silt loam; very dark brown (10YR 2/2) when dry; massive; friable, slightly sticky, slightly plastic, and weakly smeary; many roots; many very fine pores; 15 to 25 percent stones; medium acid; abrupt, wavy boundary. (5 to 8 inches thick)

B22—14 to 18 inches, dark reddish-brown (5YR 3/2) very stony silt loam; dark yellowish brown (10YR 3/4) when dry; massive; friable, slightly plastic, slightly sticky, and weakly smeary; common roots; many very fine pores; 25 to 50 percent stones; medium acid; abrupt, wavy boundary. (1 to 6 inches thick)

IIR—18 inches, pahoehoe lava.

The depth to pahoehoe lava bedrock ranges from 10 to 20 inches. Stone-size fragments of Aa lava make up 10 to 50 percent of the soil mass. The chroma is 1 or 2 when the soil is moist. The B horizon is weakly to moderately smeary.

Included with this soil in mapping are small areas of pahoehoe lava outcrops and a few cinder cones.

Permeability is rapid, runoff is slow, and the erosion hazard is slight. Roots are matted over the pahoehoe lava, or they penetrate the cracks.

This soil is used for woodland and pasture. (Capability subclass VIIs, nonirrigated; pasture group 10; woodland group 11)

Puukala very rocky silt loam, 6 to 12 percent slopes (PTC).—This soil is similar to Puukala extremely stony silt loam, 6 to 12 percent slopes, except that pahoehoe lava outcrops occupy about 10 percent of the surface. The silt loam is typically about 15 inches deep, but it is shallower near the rock outcrops.

This soil is used for woodland and pasture. (Capability subclass VIs, nonirrigated; pasture group 10; woodland group 11)

Puu Oo Series

The Puu Oo series consists of well-drained silt loams that formed in volcanic ash. These are gently sloping to moderately steep soils on uplands. They are at an elevation ranging from 5,000 to 6,500 feet and receive from 65 to 100 inches of rainfall annually. The mean annual soil temperature is between 53° and 56° F. The natural vegetation consists of ohia, alapaio fern, tree fern, koa, sweet vernal, and white clover. These soils and Laumaia, Maile, and Piihonua soils are in the same general area.

Puu Oo soils are used for pasture.

Puu Oo silt loam, 6 to 12 percent slopes (PUC).—This soil is at intermediate elevations on the windward side of Mauna Kea.

In a representative profile the surface layer is dark reddish-brown and very dark gray silt loam about 6 inches thick. The subsoil is very dark brown to dark reddish-brown silty clay loam about 21 inches thick. It is underlain by dark yellowish-brown and dark-brown sandy clay loam. The subsoil dehydrates irreversibly into fine sand-size aggregates. The surface layer is strongly acid and very strongly acid. The subsoil and underlying material are extremely acid, very strongly acid, and strongly acid.

Representative profile, Pua Akala Quadrangle, lat. 19°46′20″ N. and long. 155°20′25″ W.:

A11—0 to 3 inches, dark reddish-brown (5YR 2/2) silt loam; moderate, fine, granular structure; friable, slightly sticky, plastic, and weakly smeary; many roots; many very fine pores; strongly acid; clear, smooth boundary. (2 to 4 inches thick)

A12—3 to 6 inches, very dark gray (5YR 3/1) silt loam; moderate, fine, subangular blocky structure; friable, slightly sticky, plastic, and weakly smeary; many roots; many fine pores; a few, scattered, black, fine pieces of charcoal; very strongly acid; abrupt, smooth boundary. (3 to 4 inches thick)

B1—6 to 9 inches, dark reddish-brown (5YR 3/3) silty clay loam; moderate, fine, subangular blocky structure; friable, sticky, plastic, and moderately smeary; many roots; many fine pores; patchy, gelatinlike coatings on peds; extremely acid; abrupt, wavy boundary. (2 to 5 inches thick)

B21—9 to 16 inches, very dark brown (10YR 2/2) silty clay loam; moderate, fine, subangular blocky structure; friable, sticky, plastic, and moderately smeary; many roots; many fine pores; thick, gelatinlike coatings on peds; very strongly acid; abrupt, smooth boundary. (5 to 7 inches thick)

B22—16 to 22 inches, variegated colors of very dark brown (10YR 2/2), dark-brown (7.5YR 4/4), very dark gray (N 3/0), and dark reddish-brown (5YR 3/4) silty clay loam; massive; friable, sticky, plastic, and strongly smeary; common roots; many fine pores; common, firm, weakly cemented ash nodules; very strongly acid; abrupt, smooth boundary. (5 to 6 inches thick)

B23—22 to 27 inches, very dark grayish-brown (10YR 3/2) silty clay loam; moderate, medium and fine, subangular blocky structure; friable, sticky, plastic, and strongly smeary; common roots; many fine pores; thick, gelatinlike coatings on peds; very strongly acid; abrupt, smooth boundary. (5 to 8 inches thick)

IIC—27 to 50 inches, variegated colors of dark yellowish-brown (10YR 3/4) and dark-brown (7.5YR 4/4 and 7.5YR 3/2) sandy clay loam; massive; extremely firm, slightly sticky, plastic, and weakly smeary; few roots; many fine pores; thick, gelatinlike coatings on ped faces; weakly cemented layer of volcanic ash and sand 2 to 4 inches thick; strongly acid.

This soil is nonstony to very stony. The A horizon ranges from 5YR to 10YR in hue. In places there is a thin, red layer or a black layer immediately below the A horizon. The B2 horizon is moderately smeary to strongly smeary in the lower part and has hues ranging from 5YR to 10YR. The B horizon dehydrates irreversibly into very hard, dark-brown or black aggregates the size of sand and silt.

Permeability is moderately rapid, runoff is slow, and the erosion hazard is slight. Roots can penetrate to a depth of 3 feet or more.

This soil is used for pasture. (Capability subclass IIIe, nonirrigated; pasture group 11; woodland group 8)

Puu Pa Series

The Puu Pa series consists of well-drained stony very fine sandy loams that formed in volcanic ash. These soils are gently sloping to extremely steep, and most areas are extremely stony. They are on uplands at an elevation ranging from 1,000 to 2,500 feet and receive from 20 to 35 inches of rainfall annually. Their mean annual soil temperature is between 69° and 71° F. The natural vegetation consists of bermudagrass, swollen fingergrass, lantana, ilima, and cactus. These soils and Kamakoa, Kawaihae, Mahukona, Waikaloa, and Waimea soils are in the same general area.

Puu Pa soils are used for pasture.

Puu Pa extremely stony very fine sandy loam, 6 to 20 percent slopes (PVD).—This soil is low on the leeward side of Hualalai, Mauna Kea, and the Kohala Mountains.

In a representative profile the surface layer is very dark brown extremely stony very fine sandy loam about 6 inches thick. The next layer is dark-brown and dark yellowish-brown very stony very fine sandy loam about 34 inches thick. It is underlain by fragmental Aa lava. The reaction is medium acid to slightly acid in the surface layer and neutral in the substratum. In places the surface layer is silt loam.

Representative profile, Kawaihae Quadrangle, lat. 20°01′38″ N. and long. 155°45′15″ W.:

A11—0 to 2 inches, very dark brown (10YR 2/2) extremely stony very fine sandy loam; weak, fine, granular structure; soft, very friable, nonsticky, and nonplastic; many roots; many fine pores; stones cover 50 percent of the surface; medium acid; clear, smooth boundary. (2 to 3 inches thick)

A12—2 to 6 inches, very dark brown (7.5YR 2/2) stony very fine sandy loam; weak, fine, granular structure; soft,

friable, nonsticky, and nonplastic; many roots; many very fine pores; stones and gravel make up 30 percent of horizon; slightly acid; abrupt, smooth boundary. (3 to 5 inches thick)

AC—6 to 20 inches, dark-brown (7.5YR 3/2) very stony very fine sandy loam; weak, fine, subangular blocky structure; soft, friable, nonsticky, and nonplastic; many roots; many fine pores; stones and gravel make up 40 percent of horizon; neutral; clear, wavy boundary. (12 to 16 inches thick)

C—20 to 40 inches, dark yellowish-brown (10YR 3/4) very stony very fine sandy loam; weak, fine, subangular blocky structure; friable, nonsticky, and nonplastic; common roots; many very fine pores; patches of soft, powdery lime; stones and gravel make up 50 to 70 percent of horizon and increase with depth; neutral.

II—40 inches, Aa lava and very little soil material.

The depth to fragmental Aa lava ranges from 20 inches to more than 40 inches. The depth to soft powdery lime ranges from 20 to 40 inches. In some places this lime encrusts the gravel and stones. The A horizon has a value of 2 or 3 and a hue of 10YR to 5YR. Below the A horizon, the chroma and value range from 2 to 4.

Included in mapping near Puuwaawaa Hill are small, nonstony areas. Also included are cinder cones.

Permeability is moderately rapid, runoff is medium, and the erosion hazard is moderate. Roots penetrate to the fragmental Aa lava.

This soil is used for pasture. (Capability subclass VIIs, nonirrigated; pasture group 2)

Puu Pa extremely stony very fine sandy loam, 70 to 100 percent slopes, severely eroded (PVF3).—This soil is near the Puuwaawaa Ranch. The average slope is about 90 percent. This soil is so severely eroded that in most areas only a thin soil layer is left over weathering trachyte. The hazard of further erosion is very severe. Runoff is very rapid.

This soil is used for wildlife habitat and watershed. (Capability subclass VIIIs, nonirrigated)

Puu Pa silt loam, 12 to 20 percent slopes (PWD).—This soil is near Puuwaawaa Ranch. The dominant slope is about 13 percent. The depth to weathering trachyte is more than 48 inches. Runoff is medium, and the hazard of erosion is moderate.

This soil is used for pasture. (Capability subclass IVe, nonirrigated; pasture group 2)

Rock Land

Rock land (rRO) is a miscellaneous land type that consists of pahoehoe lava bedrock covered in places by a thin layer of soil material. The dominant slope is between 10 and 15 percent. Pahoehoe outcrops occupy 50 to 90 percent of the surface. The average depth of the soil material is between 6 and 8 inches, although in some places the material extends into the cracks of the lava. Rock land is at an elevation ranging from near sea level to 13,000 feet and receives from 10 inches to more than 150 inches of rainfall annually. The vegetation is confined mainly to the soil-covered areas and the cracks in the lava. It varies according to rainfall and temperature, and suffers from drought during dry spells. The hazard of water erosion is slight. Rock land is used for pasture, wildlife habitat, and watershed. (Capability subclass VIIs, nonirrigated)

Rough Broken Land

Rough broken land (RB) is a miscellaneous land type that consists of very steep, precipitous land broken by many intermittent drainage channels. It occurs primarily in gulches, and the slope is dominantly 35 to 70 percent. The soil material ranges from very shallow to deep. Stones and rock outcrops are common in some areas. Elevation ranges from near sea level to 3,000 feet, and the annual rainfall ranges from 50 inches to more than 150 inches. Vegetation varies with rainfall. Kukui trees are common in the gulches. There are a few, scattered waterfalls.

Rough broken land is used for pasture, woodland, wildlife habitat, and recreation areas. Adapted pasture plants and yields are similar to those for soils associated with this land type. (Capability subclass VIIe, nonirrigated)

Tropaquepts

Tropaquepts (Tr) are a miscellaneous land type that consists of moderately deep, poorly drained soils forming in recent alluvium. The alluvium has washed from soils that formed in volcanic ash. Tropaquepts are in the Waipio, Waimanu, and Pololu Valleys. They are at an elevation ranging from sea level to 500 feet and receive 60 to 100 inches of rainfall annually. Their dominant properties are the result of poor drainage induced by man.

Tropaquepts have a surface layer of dark-gray mucky silt loam and a subsoil of silty clay loam. Their substratum consists of very fine sand and gravel, prominently mottled with gray, yellow, and red. The depth to the water table is less than 20 inches. Tropaquepts are frequently flooded.

The natural vegetation consists of hilograss, guava, honohonograss, and monkey pod. In the Waimanu and Pololu Valleys, these soils were formerly used for growing rice and taro. They are now used for wildlife habitat. In the Waipio Valley these soils are used for taro. (Capability subclass IVw, irrigated, and IVw, nonirrigated; pasture group 6; woodland group 3)

Umikoa Series

The Umikoa series consists of well-drained silt loams that formed in volcanic ash. These are moderately sloping to moderately steep soils on uplands. They are at an elevation ranging from 3,500 to 5,000 feet and receive from 40 to 65 inches of rainfall annually. The mean annual soil temperature is between 55° and 58° F. The natural vegetation consists of kikuyugrass, sweet vernal, rattail, and yorkshire fog. These soils and Hanipoe and Maile soils are in the same general area.

Umikoa soils are used for pasture and woodland.

Umikoa silt loam, 12 to 20 percent slopes (UMD).—This soil is at intermediate elevations on the windward side of Mauna Kea.

In a representative profile the surface layer is dark-brown silt loam about 5 inches thick. The subsoil is dark-brown and very dark grayish-brown silty clay loam about 55 inches thick. The substratum is fragmental Aa lava. This soil is slightly acid in the surface

layer and slightly acid to medium acid in the subsoil. In places the surface is extremely stony.

Representative profile, Umikoa Quadrangle, lat. 19°58′15″ N. and long. 155°22′52″ W.:

A1—0 to 5 inches, dark-brown (7.5YR 3/4) silt loam; weak, very fine, granular structure; soft, very friable, nonsticky, and slightly plastic; many roots; many very fine and fine pores; slightly acid; abrupt, smooth boundary. (3 to 8 inches thick)

B1—5 to 12 inches, dark-brown (7.5YR 3/4) silt loam; moderate, very fine, subangular blocky structure; soft, friable, slightly sticky, and slightly plastic; many roots; many very fine and fine pores; many, thin, gelatinlike coatings on ped surfaces; medium acid; clear, smooth boundary. (5 to 8 inches thick)

B21—12 to 22 inches, dark-brown (10YR 3/3) silty clay loam; moderate, very fine and fine, subangular blocky structure; soft, friable, sticky, and plastic; many roots; many very fine and fine pores; many, thin, gelatinlike coatings on ped surfaces; a hard layer of volcanic ash is present in this horizon; this layer resists erosion and is prominent on roadbanks where it protrudes from the banks; slightly acid; abrupt, wavy boundary. (8 to 15 inches thick)

B22—22 to 33 inches, very dark grayish-brown (10YR 3/2) silty clay loam; moderate, very fine and fine, subangular blocky structure; soft, friable, slightly sticky, and plastic; common roots; many very fine and fine pores; few, patchy, shiny spots on ped faces; medium acid; abrupt, smooth boundary. (8 to 15 inches thick)

B23—33 to 42 inches, dark-brown (10YR 3/3) silty clay loam; moderate, very fine and fine, subangular blocky structure; soft, friable, slightly sticky, and plastic; few roots; many very fine and fine pores; few, patchy, shiny spots on ped faces; medium acid; abrupt, wavy boundary. (7 to 12 inches thick)

B24—42 to 60 inches, very dark grayish-brown (10YR 3/2) silty clay loam; moderate, very fine and fine, subangular blocky structure; slightly hard, friable, slightly sticky, and plastic; few roots; many very fine and fine pores; few, patchy, shiny spots on ped faces; many basalt fragments from pebble to stone size in the lower part of this horizon; medium acid; abrupt, wavy boundary. (12 to 25 inches thick)

IIC—60 inches, fragmental Aa lava.

The depth to unconforming Aa lava ranges from 42 inches to more than 60 inches. This soil is usually moist. The A1 horizon has weak to moderate structure. It ranges from 5YR to 10YR in hue, and from 2 to 4 in chroma and value. Pockets of dark-red material occur immediately below the A horizon in places, especially at higher elevations. In places the lower part of the B horizon is weakly smeary.

Permeability is moderately rapid, runoff is slow to medium, and the erosion hazard is moderate. Roots can penetrate to a depth of 42 inches or more.

This soil is used for pasture and woodland. (Capability subclass IVe, nonirrigated; pasture group 12; woodland group 9)

Umikoa extremely stony silt loam, 12 to 20 percent slopes (USD).—This soil is similar to Umikoa silt loam, 12 to 20 percent slopes, except that stones cover 3 to 15 percent of the surface. (Capability subclass VIIs, nonirrigated: pasture group 12; woodland group 9)

Very Stony Land

Very stony land (rVS) is a miscellaneous land type consisting of very shallow soil material and a high proportion of Aa lava outcrops. The dominant slope is between 10 and 15 percent. Between the lava outcrops and in the cracks of the lava, the soil material extends to a depth of 5 to 20 inches. This land is at an elevation ranging from near sea level to 13,000 feet and receives from 10 inches to more than 150 inches of rainfall annually. The vegetation ranges from a sparse cover in dry areas to dense stands of ohia and tree fern in areas of high rainfall. The erosion hazard is slight.

This land is used for pasture and watershed and for wildlife habitat. Adapted pasture plants and yields are similar to those of surrounding soils. (Capability subclass VIIs, nonirrigated)

Waiaha Series

The Waiaha series consists of shallow, well-drained silt loams that formed in volcanic ash. These soils are nearly level to moderately steep and most areas are extremely stony. They are on uplands at an elevation ranging from near sea level to 1,000 feet. They receive from 20 to 40 inches of rainfall annually, most of which falls during the summer months, except in the Pahala area. The mean annual soil temperature is between 72° and 74° F. The natural vegetation consists of kiawe, koa haole, natal redtop, lantana, guineagrass, and bermudagrass. These soils and Kaimu, Kainaliu, and Punaluu soils are in the same general area.

Waiaha soils are used for pasture.

Waiaha extremely stony silt loam, 6 to 12 percent slopes (WHC).—This soil is low on the leeward side of Hualalai and Mauna Loa.

In a representative profile the surface layer is very dark brown extremely stony silt loam about 4 inches thick. The subsoil is dark-brown very stony silt loam about 14 inches thick. The substratum is pahoehoe lava bedrock. The surface layer is slightly acid. The subsoil is neutral to mildly alkaline. In places the surface layer is nonstony.

Representative profile, Kealakekua Quadrangle, lat. 19°32′12″ N. and long. 155°56′47″ W.:

A1—0 to 4 inches, very dark brown (10YR 2/2) extremely stony silt loam; dark brown (10YR 4/3) when dry; weak, fine and very fine, granular structure; soft, friable, nonsticky, and slightly plastic; many roots; many very fine and fine pores; stones make up 5 to 10 percent of the horizon; slightly acid; clear, wavy boundary. (3 to 6 inches thick)

B21—4 to 10 inches, dark-brown (7.5YR 3/2) stony silt loam; strong brown (7.5YR 4/6) when dry; weak, fine and very fine, subangular blocky structure; slightly hard, friable, nonsticky, and nonplastic; many roots; many very fine and fine pores; basalt fragments make up about 15 percent of the horizon; neutral; clear, wavy boundary. (6 to 8 inches thick)

B22—10 to 18 inches, dark-brown (7.5YR 3/3) very stony silt loam; dark brown (7.5YR 4/4) when dry; weak, fine and very fine, subangular blocky structure; a few small pockets of material that is massive; slightly hard, friable, slightly sticky, and slightly plastic; common roots; many very fine and fine pores; scattered remnants of sea shells; mildly alkaline; clear, wavy boundary; basalt fragments ranging from gravel to stone size make up about 50 percent of the horizon. (6 to 8 inches thick)

IIR—18 inches, hard pahoehoe lava.

The depth to underlying pahoehoe lava bedrock ranges from 15 to 20 inches. The structure of the A horizon ranges from weak to moderate. Near sea level, calcium carbonate encrusts the rocks or extends into the cracks of the bedrock.

Permeability is moderately rapid, runoff is slow, and the erosion hazard is slight. Roots can penetrate to bedrock. (Capability subclass VIIs, nonirrigated; pasture group 3)

Waiaha very rocky silt loam, 10 to 20 percent slopes (WKD).—This soil is similar to Waiaha extremely stony silt loam, 6 to 12 percent slopes, except that the slopes are moderately steep, and pahoehoe rock outcrops occupy 10 to 25 percent of the surface. Included in mapping are small areas that have a loam surface layer.

This soil is used for pasture. (Capability subclass VIs, nonirrigated; pasture group 3)

Waiaha silt loam, 0 to 10 percent slopes (WAC).—This soil is similar to Waiaha extremely stony silt loam, 6 to 12 percent slopes, except that the surface layer is nonstony. Also, this soil is near Pahala and receives more rain during the winter than the extremely stony soil. Included in mapping are small areas that have a loam surface layer.

This soil is used for pasture and orchards. (Capability subclass IIIe, nonirrigated; pasture group 3; woodland group 15)

Waiaha silt loam, 10 to 20 percent slopes (WAD).—This soil is similar to Waiaha extremely stony silt loam, 6 to 12 percent slopes, except that it is nonstony. Also, it is near Pahala and receives more rain during the winter than the extremely stony soil. Runoff is medium, and the erosion hazard is moderate.

This soil is used for pasture and orchards. (Capability subclass IVe, nonirrigated; pasture group 3; woodland group 15)

Waikaloa Series

The Waikaloa series consists of well-drained very fine sandy loams that formed in volcanic ash. These soils are gently sloping to moderately sloping. They are on uplands at an elevation ranging from 1,500 to 4,500 feet and receive from 20 to 30 inches of rainfall annually. Their mean annual soil temperature is between 61° and 64° F. The natural vegetation consists of bermudagrass, natal redtop, bur clover, ilima, cactus, and mountain dandelion. These soils and Kamakoa, Kawaihae, Puu Pa, and Waimea soils are in the same general area.

Waikaloa soils are used for pasture.

Waikaloa very fine sandy loam, 6 to 12 percent slopes (WLC).—This soil is at intermediate elevations on the leeward side of Mauna Kea.

In a representative profile the surface layer is dark reddish-brown very fine sandy loam about 10 inches thick. It is underlain by about 10 inches of dark-brown very fine sandy loam. The subsoil is about 11 inches thick and consists of dark-brown and dark reddish-brown very fine sandy loam and silty clay loam. Underlying this is dark reddish-brown and dark-brown silty clay loam and sandy loam. Soft, powdery lime occurs at a depth of 20 to 60 inches. The surface layer is neutral, and the subsoil is mildly alkaline.

Representative profile, Nohonaohae Quadrangle, lat. 19°53′30″ N. and long. 155°43′10″ W.:

Ap—0 to 5 inches, dark reddish-brown (5YR 2/2) very fine sandy loam; dark brown (7.5YR 4/2) when dry; weak, fine, granular structure; soft, very friable, nonsticky, and nonplastic; many roots; many fine and very fine pores; neutral; abrupt, smooth boundary. (4 to 7 inches thick)

A1—5 to 10 inches, dark reddish-brown (5YR 3/2) very fine sandy loam; dark brown (7.5YR 4/4) when dry; weak, fine, granular structure; soft, very friable, nonsticky, and nonplastic; many roots; many fine and very fine pores; neutral; clear, smooth boundary. (3 to 8 inches thick)

A3—10 to 20 inches, dark-brown (7.5YR 3/4) very fine sandy loam; dark brown (7.5YR 4/4) when dry; weak, coarse, prismatic structure; slightly hard, very friable, nonsticky, and nonplastic; many roots; many fine and very fine pores; neutral; gradual, wavy boundary. (7 to 12 inches thick)

B21—20 to 25 inches, dark-brown (7.5YR 3/4) very fine sandy loam; dark brown (7.5YR 4/4) when dry; weak, coarse, prismatic structure; slightly hard, friable, nonsticky, and nonplastic; many roots; many fine pores; neutral; gradual, wavy boundary. (3 to 6 inches thick)

IIB22b—25 to 31 inches, dark reddish-brown (5YR 3/4) silty clay loam; dark brown (7.5YR 4/4) when dry; weak, coarse, prismatic structure; hard, friable, slightly sticky, and plastic; common roots; many very fine pores; neutral; gradual, wavy boundary. (3 to 7 inches thick)

IIC1cab—31 to 39 inches, dark reddish-brown (5YR 3/2) silty clay loam; strong brown (7.5YR 5/6) when dry; weak, coarse, prismatic structure; hard, friable, slightly sticky, and plastic; common roots; many very fine pores; violent effervescence with dilute hydrochloric acid; mildly alkaline; clear, wavy boundary. (7 to 12 inches thick)

IIC2cab—39 to 50 inches, dark-brown (7.5YR 3/4) silty clay loam; light yellowish brown (10YR 6/4) when dry; weak, coarse, prismatic structure; hard, friable, slightly sticky, and plastic; few roots; many very fine pores; a strongly cemented layer about one inch thick occurs at a depth of 42 inches; strong effervescence with dilute hydrochloric acid; mildly alkaline; abrupt, wavy boundary. (10 to 15 inches thick)

IIC3b—50 to 65 inches, dark-brown (7.5YR 4/4) sandy loam; light yellowish brown (10YR 6/4) when dry; weak, coarse, prismatic structure; hard, friable, nonsticky, and nonplastic; few roots; many very fine pores; no effervescence with dilute hydrochloric acid; mildly alkaline.

The depth to bedrock ranges from 32 inches to more than 65 inches. The hue of the solum is 5YR to 10YR. The A horizon, when dry, has a chroma and value of 2 to 4. The depth to the IICca horizon ranges from 20 to 40 inches. The texture of the IICca horizon is silt loam to silty clay loam.

Included in mapping are about 50 acres of severely eroded Waikaloa soils. Scattered, small areas of stony Waikaloa soils are also included.

Permeability is moderate, runoff is medium, and the erosion hazard is moderate. Roots can penetrate to a depth of 6 feet.

This soil is used for pasture. (Capability subclass IIIe, nonirrigated; pasture group 4; woodland group 1)

Waimea Series

The Waimea series consists of well-drained very fine sandy loams that formed in volcanic ash. These soils are gently sloping to moderately steep. They are on uplands at an elevation ranging from 2,000 to 6,000 feet and receive from 25 to 45 inches of rainfall annually. Their mean annual soil temperature is between 59° and 62° F. The natural vegetation consists of cactus, bermudagrass, rattail, and ilima. These soils and Kikoni, Palapalai,

Puu Pa, and Waikaloa soils are in the same general area.

Waimea soils are used for pasture and truck crops.

Waimea very fine sandy loam, 6 to 12 percent slopes (WMC).—This soil is at intermediate elevations on the leeward side of Mauna Kea and the Kohala Mountains.

A representative profile has a surface layer about 17 inches thick. This layer consists of dark-brown and very dark brown very fine sandy loam and loam. The subsoil is dark-brown silt loam about 25 inches thick. It is underlain by weathering, hard basalt bedrock at a depth of about 42 inches. The surface layer is neutral; the subsoil is mildly alkaline. In places the surface is extremely stony.

Representative profile, Kamuela Quadrangle, lat. 20°03′18″ N. and long. 155°44′40″ W.:

A11—0 to 2 inches, very dark brown (7.5YR 2/2) very fine sandy loam; dark brown (7.5YR 3/3) when dry; weak, very fine and fine, granular structure; soft, very friable, nonsticky, and nonplastic; many roots; many fine pores; neutral; abrupt, smooth boundary. (2 to 3 inches thick)

A12—2 to 7 inches, dark-brown (7.5YR 3/2) very fine sandy loam; (7.5YR 3/4) when dry; massive; soft, very friable, nonsticky, and nonplastic; many roots; many very fine and fine pores; neutral; clear, smooth boundary. (5 to 7 inches thick)

A13—7 to 17 inches, dark-brown (7.5YR 3/3) loam; dark brown (7.5YR 4/4) when dry; massive; soft, very friable, nonsticky, and nonplastic; many roots; many very fine and fine pores; 10 to 20 percent basalt fragments from gravel to stone size; mildly alkaline; gradual, wavy boundary. (10 to 15 inches thick)

B21—17 to 31 inches, dark-brown (7.5YR 3/3) silt loam; dark brown (7.5YR 4/4) when dry; weak, fine and medium, subangular blocky structure; soft, very friable, nonsticky, and nonplastic; many roots; many very fine and fine pores; 20 to 30 percent basalt fragments from gravel to stone size; mildly alkaline; gradual, wavy boundary. (10 to 15 inches thick)

B22—31 to 42 inches, dark-brown (7.5YR 3/3) silt loam; dark brown (7.5YR 4/4) when dry; weak, fine and medium, subangular blocky structure; soft, very friable, slightly sticky, and slightly plastic; many roots; many very fine and fine pores; 30 to 40 percent basalt fragments of gravel to stone size; mildly alkaline; abrupt, wavy boundary. (9 to 15 inches thick)

IIR—42 inches, weathering hard basalt.

The depth to bedrock ranges from 36 to 55 inches. The solum ranges from 10YR to 5YR in hue. It has a value and chroma of 2 or 3 when moist and 3 or 4 when dry. The B horizon ranges from loam to silt loam in texture and is massive or has weak structure.

Permeability is moderately rapid, runoff is slow, and the erosion hazard is slight. The available water capacity is about 1.8 inches per foot of soil. Roots can penetrate to a depth of 30 inches or more.

This soil is used for pasture and for irrigated truck crops. (Capability subclass IIIe, irrigated, and IIIe, nonirrigated; pasture group 4; woodland group 1)

Waimea extremely stony very fine sandy loam, 12 to 20 percent slopes (WSD).—This soil is similar to Waimea very fine sandy loam, 6 to 12 percent slopes, except that the slopes are moderately steep, and stones cover 3 to 15 percent of the surface. Runoff is medium, and the erosion hazard is moderate.

This soil is used for pasture. (Capability subclass VIIs, nonirrigated; pasture group 4; woodland group 1)

Use and Management of the Soils

Soils are used for the production of plants and support of animals and as structural material for engineering purposes. Thus, this section has two main parts—management of soils for farming and related uses, which include woodland and wildlife habitat, and management of soils for the construction of highways, the support of buildings, and other engineering uses.

Management of the Soils for Farming and Related Uses

This section discusses the suitability and management of the soils for crops and pasture, for woodland, and for wildlife habitat.

Management groups

For convenience in planning the management of soils, they are placed in management groups according to their suitability for specific uses. One grouping described in this section is the capability system used by the Soil Conservation Service (*21*). This system is adapted to soils throughout the country to show their suitability for most kinds of crops. Other groupings described are those for sugarcane, pasture, and woodland and for wildlife habitat. These groupings are adapted to the specialized uses of the soils of the island. In the description of each group the soil features that affect management are given, as well as estimated yields and suggested practices. Only the soils suited to these specific uses have been placed in these groups. Some of the stony soils and the land types, for example, have not been placed in the sugarcane groups because they are unsuited or are too variable. The "Guide to Mapping Units" lists the groups in which each soil has been placed.

Crops and pasture

Many factors affect the use of soils for crops and pasture. Some important factors are temperature, relief, drainage, depth of soil, stoniness, availability of water, amount of solar insolation, and accessibility and suitability for use of mechanized equipment. These factors are reflected in the grouping of the soils and in the management suggested. Management refers to such practices as soil preparation, selection of crops, application of fertilizer, use of crop residue, and control of soil and water loss. Practices vary between plantations, but in general a high level of management is practiced on the island.

Capability grouping

Capability grouping shows, in a general way, the suitability of soils for most kinds of field crops. The groups are made according to the limitations of the soils when used for field crops, the risk of damage when they are used, and the way they respond to treatment. The grouping does not take into account major and generally expensive landforming that would change slope, depth, or other characteristics of the soils; does not take into consideration possible but unlikely major reclamation projects; and does not apply to rice, cranberries, horticultural crops, or other crops requiring special management.

Those familiar with the capability classification can infer from it much about the behavior of soils when used for other purposes, but this classification is not a substitute for interpretations designed to show suitability and limitations of groups of soils for range, for forest trees, or engineering.

In this publication, all of the soils are grouped at two levels, the capability class, and the subclass. The classification is designated in the "Guide to Mapping Units" for all soils on the island, both irrigated and nonirrigated soils. The classification is described in the following pages.

Capability Classes, the broadest groups, are designated by Roman numerals I through VIII. The numerals indicate progressively greater limitations and narrower choices for practical use, defined as follows:

- Class I soils have few limitations that restrict their use.
- Class II soils have moderate limitations that reduce the choice of plants or that require moderate conservation practices.
- Class III soils have severe limitations that reduce the choice of plants, require special conservation practices, or both.
- Class IV soils have very severe limitations that reduce the choice of plants, require very careful management, or both.
- Class V soils are not likely to erode but have other limitations, impractical to remove, that limit their use largely to pasture, range, woodland, or wildlife.
- Class VI soils have severe limitations that make them generally unsuited to cultivation and limit their use largely to pasture or range, woodland, or wildlife.
- Class VII soils have very severe limitations that make them unsuited to cultivation and that restrict their use largely to pasture or range, woodland, or wildlife.
- Class VIII soils and landforms have limitations that preclude their use for commercial plants and restrict their use to recreation, wildlife, or water supply, or to esthetic purposes.

Capability Subclasses are soil groups within one class; they are designated by adding a small letter, *e*, *w*, *s*, or *c*, to the class numeral, for example, IIe. The letter *e* shows that the main limitation is risk of erosion unless close-growing plant cover is maintained; *w* shows that water in or on the soil interferes with plant growth or cultivation (in some soils the wetness can be partly corrected by artificial drainage); *s* shows that the soil is limited mainly because it is shallow, droughty, or stony; and *c*, used in only some parts of the United States, shows that the chief limitation is climate that is too cold or too dry.

In class I there are no subclasses, because the soils of this class have few limitations. Class V can contain, at the most, only the subclasses indicated by *w*, *s*, and *c*, because the soils in class V are subject to little or no erosion, though they have other limitations that restrict their use largely to pasture, range, woodland, wildlife, or recreation.

Sugarcane

Sugarcane is the principal crop on the Island of Hawaii. It is grown on the windward slopes of Mauna Kea and the Kohala Mountains and on the southern slopes of Mauna Loa. Sugarcane generally is not irrigated, except for the acreage on the Kohala, Honokaa, and Paauhau soils at low elevations where the rainfall is relatively low and solar insolation is high.

Sugarcane is harvested every 20 to 36 months, depending on the variety of cane and the climate. Replanting generally is not necessary, because after the cane is harvested the root system sends up new sprouts, or shoots, to produce the next crop. Replanting is common, however, to introduce a new variety, alter the irrigation or field layout, relieve undue compaction of the soil, or change the cropping system.

The sugarcane industry is highly mechanized. The use of heavy equipment permits the production of sugarcane in some areas that otherwise would be considered unsuited for cultivation.

The present method of harvesting sugarcane consists of burning the cane fields to remove excess leaves. Immediately after burning, a mechanical push rake pushes the cane stalks into piles. Large cranes load the stalks into trucks that transport the cane to the mill. These operations disturb the soil and increase the erosion hazard, but the hazard can be minimized by harvesting the crop during periods of low rainfall and by allowing time for regrowth of the crop before periods of high rainfall. Soil erosion can be controlled by constructing grassed waterways, irrigating and planting on the contour, lining ditches and canals, and using diversion ditches (fig. 10).

To establish a new planting of sugarcane, the fields are smoothed, subsoiled, or disk-plowed, and harrowed. If the field is to be irrigated, the irrigation, drainage, and road systems are installed. Terraces, diversions, grassed waterways, and roads are installed in nonirrigated areas. After these operations are completed, the seed stalk is planted by machine or by hand. The stalk is planted in the bottom of a machine-opened furrow and covered with a few inches of soil. The furrows are laid out on the contour to minimize erosion. After harvest the common practice is to reshape and repair the furrows, terraces, diversions, roads, waterways, and ditches.

Fertilizer is applied by hand, machine, or airplane or in irrigation water. The soils respond readily to applications of nitrogen, phosphorus, and potassium. Lime is needed on some soils. The kind and amounts of fertilizer are best determined by soil tests, tissue analysis, field trials, and experience.

Insecticides are applied as needed to control insects. Weeds are controlled by herbicides and hand weeding.

SUGARCANE GROUP 1

This group consists of well-drained to somewhat excessively drained silty clay loams and silty clays that have a slope of 0 to 35 percent. These soils have moderate to moderately rapid permeability, slow to rapid runoff, and a slight to severe hazard of erosion. They hold about 1.5 to 1.8 inches of water available per foot of soil. Their rooting depth is 36 to 60 inches or more.

Figure 10.—**Diversion ditch in sugarcane field on Paauhau silty clay loam.**

They receive 20 to 80 inches of rainfall annually. The amount of solar insolation is high. The mean annual soil temperature is 72° F. or more.

These soils are irrigated by sprinkler systems or by furrows from ditches or aluminum and concrete flumes. The furrows have a gradient of 0.5 to 1.5 percent. The field layout and tillage practices are across the slope, nearly on the contour. Diversions and secondary field roads are also across the slope and serve to remove runoff water. Young cane is alternated with old cane in strips. The width of the strips and the spacing of diversions are determined by the kind of soil, the length and gradient of slope, and the intensity and frequency of rainfall.

On soils that have a slope greater than 20 percent, special equipment and special land preparation, planting, and harvesting are required to minimize field damage and soil and water losses.

Yields are 8 to 12 tons per acre per crop.

SUGARCANE GROUP 2

This group consists of well-drained silty clay loams that have a slope of 0 to 35 percent. These soils have moderately rapid to rapid permeability, slow to rapid runoff, and a slight to severe erosion hazard. Their rooting depth is 10 to 60 inches or more. They receive 35 to 180 inches of rainfall annually, and the soils in the lower rainfall areas become droughty during the summer. The total solar insolation is relatively high. The mean annual soil temperature is 72° F. or more.

These soils are not irrigated. The field layout and tillage practices are across the slope, nearly on the contour. The diversions and secondary field roads are also across the slope and serve to remove runoff water. Young cane is alternated with old cane in strips. The width of the strips and the spacing of diversions are determined by the kind of soil, the length and gradient of the slope, and the intensity and frequency of rainfall.

On soils that have a slope greater than 20 percent, special equipment and special land preparation, planting, and harvesting are required to minimize field damage and soil and water losses.

Yields are 7 to 11 tons of sugar per acre per crop.

SUGARCANE GROUP 3

This group consists of well-drained silty clay loams that have a slope of 0 to 35 percent. Some of these soils dehydrate irreversibly into fine sand-size aggregates.

Permeability is moderately rapid to rapid, runoff is slow to rapid, and the erosion hazard is slight to severe. The rooting depth is 30 to 60 inches or more. The annual rainfall is 60 to 100 inches. The amount of solar insolation is relatively low, and the mean annual soil temperature is between 68° and 71° F.

These soils are not irrigated. The field layout and tillage practices are across the slope, nearly on the contour. Diversions and secondary field roads are also across the slope and serve to remove runoff water. Young cane is alternated with old cane in strips. The width of the strips and the spacing of diversions are determined by the kind of soil, the length and gradient of the slope, and the intensity and frequency of rainfall.

On soils that have a slope greater than 20 percent, special equipment and special land preparation, planting, and harvesting methods are required to minimize field damage and soil and water losses.

Yields are 6 to 9 tons of sugar per acre per crop.

SUGARCANE GROUP 4

This group consists of moderately well drained to well drained silty clay loams that have a slope of 0 to 35 percent. Some of these soils dehydrate irreversibly into very hard, fine gravel-size aggregates. Trafficability is poor. Permeability is rapid, runoff is slow to rapid, and the erosion hazard is slight to severe. The rooting depth is 10 to 60 inches or more. The annual rainfall is 80 to 300 inches or more. The amount of solar insolation is low, and the mean annual soil temperature is between 56° and 70° F.

These soils receive more than adequate rainfall to produce sugarcane without irrigation. The field layout and tillage practices are across the slope, nearly on the contour. Young cane is alternated with old cane in strips. Diversions and secondary field roads are also across the slope and serve to remove runoff water. The width of the strips and the spacing of the diversions are determined by the kind of soil, the length and gradient of slope, and the intensity and frequency of rainfall. Harvesting is scheduled during the dry months to minimize field damage and to allow the regrowth of sugarcane before the wetter season begins.

On soils that have a slope greater than 20 percent, special equipment and special land preparation, planting, and harvesting are required to minimize field damage and soil and water losses.

Yields are 6 to 9 tons of sugar per acre per crop.

Diversified crops

Truck crops, papaya, bananas, macadamia nuts, and coffee are some of the important crops grown in addition to sugarcane. In 1967 about 18,540 acres were used for such crops. About one-fourth of this was used for coffee and one-fourth for macadamia nuts.

Truck crops.—Lettuce, cucumbers, tomatoes, snap beans, daikon (white radish), and Chinese cabbage (fig. 11) are grown for the Honolulu market, for home use, and to supply other areas when vegetables are out of season. Broccoli, corn, eggplant, peppers, ginger root, onions, and taro are also grown, but in small quantities. Vegetables are grown mainly in the Waimea, Kona, and Volcano districts. Because of the tropical climate, there is an all-year growing season, and in most areas at least two crops of vegetables can be grown in a year.

In preparation for truck crops, the soil is first disk harrowed to chop plant residue. This is followed by plowing, disking, harrowing, and smoothing. Areas of extremely stony mucky soils are cleared with a dozer, then smoothed and rolled. Sugarcane bagasse is spread over the area for a mulch. Soil fumigants are used before planting to control nematodes.

The soils used for vegetables respond readily to nitrogen, phosphorus, and potassium. The amount and kind of fertilizer and the time to apply it depend on the soil and the crop. Fertilizer is applied in dry form or by foliar application. Minor elements and lime are added as needed. The rate and kind of fertilizer to apply are best indicated by soil tests, field trials, and experience.

Vegetable crops are irrigated by overhead sprinklers or by furrows, and they generally require frequent irrigation.

Weeds are controlled by pre-emergence herbicides soon after planting. Contact herbicides are applied after the crop begins to grow. Mechanical and hand weeding are also common methods of weed control.

Insects and fungus are controlled by seed treatment and by insecticides applied by spraying or dusting.

Papaya.—This is a herbaceous plant commonly referred to as a tree. It has a single, erect, hollow stem surmounted with a crown of large leaves. The melonlike fruit is spherical to oblong in shape.

The tree grows rapidly, requiring only 10 to 14 months from the time of germination of the seed to the harvesting of the first ripe fruit.

Papaya grows well along the coastal plains and the foothills where temperature and solar insolation are high. Most of the papaya plantings are in the Kapoho area where the soils are extremely stony and shallow over fragmental Aa lava. The solo papaya is the most common variety grown.

Preparation for planting consists of clearing the forest of ohia trees, shaping and smoothing, and rolling with a heavy roller or drum. On fragmental Aa, a small hole is made and a few handfuls of soil are placed in the hole together with fertilizer and a few seeds. Plantings are usually spaced 8 by 10 feet apart.

Weeds are controlled by herbicides. A complete fertilizer is applied at planting time and at intervals of 2 or 3 months.

Control of insects and plant diseases is essential for maximum yields. Phytoptera and anthracnose are the principal diseases of papaya. Mites and fruit flies need to be controlled. Yields are 40,000 to 60,000 pounds per acre per year.

Bananas.—Bananas are among the most commonly grown fruits in Hawaii. Commercial banana plants generally do not produce seeds. New plants are usually started from large suckers removed from the parent plant or from sections taken from old banana stumps. The time required to grow a crop is normally one year but depends on climate, soil, and other factors.

The two most important commercial varieties grown are Cavendish (Chinese) and Gros Michel (Bluefield). Bananas require adequate moisture throughout the year and good drainage.

Figure 11.—**Chinese cabbage planted on the contour on Kikoni very fine sandy loam.**

The Cavendish banana can be planted as close as 6 to 8 feet apart, but the Bluefield requires a spacing of 12 to 18 feet. A surface mulch and shallow cultivation help to control weeds. Supplements of manure or commercial fertilizers are applied three or more times a year, the rate depending on the kind and depth of soil, the amount of rainfall, and the size of plants.

Excess suckers are removed at least four times a year. If soil fertility is high, a new sucker can be allowed to develop every 3 months so that no more than four stalks make up a mat at any one time.

Windbreaks are planted to protect bananas in areas exposed to the trade winds. The fruit fly and other insects, in addition to nematodes, diseases, and rats, must be controlled. Bananas ripen best when they are picked green. Yields are about 20,000 pounds per acre per year.

Macadamia nuts.—Macadamia nuts are produced in the Hamakua and Kau districts and on lava soils in Hilo, Puna, and Kona. Macadamia trees grow at an elevation from sea level to about 2,500 feet (fig. 12). These trees grow in deep soils as well as in shallow soils over Aa lava (fig. 13). They grow best where the annual rainfall is 50 to 120 inches (*8*).

Only grafted trees of the best varieties should be planted in new orchards. The three most promising varieties are Kakea, Ikaika, and Keauhou. Macadamia trees take about 7 years to come into commercial production. Yields vary from 2,500 to 3,500 pounds per acre, depending on climate and soil.

A complete fertilizer is applied three to five times a year, the amount and frequency depending on soil, amount of rainfall, and size of plants.

Herbicides are used to control weeds. Control of anthracnose, nut borer, and rats is also essential.

Coffee.—The production of coffee is the island's third largest industry. Coffee is grown primarily on the Kona coast at an elevation of 800 to 2,500 feet (fig. 14). The annual rainfall is 40 to 125 inches and occurs mostly during the summer.

Guatemala (*Coffea arabica*) is the main variety planted. Seedlings are planted about 6 feet apart. The trees produce coffee berries after 3 years and may continue to bear for many years. Yields are about 20 to 25 bags of parchment per acre per year.

A complete fertilizer is applied about three times a year. Herbicides are used to control weeds.

Figure 12.—Macadamia nut orchard and a permanent grass cover that protects the soil from erosion.

Pasture [2]

Approximately 743,000 acres are used for cattle grazing on the Island of Hawaii. Ranches vary in size from 250,000 acres to small units operated by part-time ranchers. Nearly all ranches are cow-calf operations. The beef animals are generally marketed as yearlings, although some weaners are sold as feeders.

Suggested practices.—In areas of low rainfall, forage production varies extremely from year to year. When the rainfall is adequate, the green-feed period sometimes lasts from November to July. When the rainfall is low, the green-feed period is much shorter, and when there is a drought the grasses sometimes do not green up. In areas of higher rainfall, forage production is consistent from year to year. Those who manage pasture should consider the length of the green-feed period and make full use of the feed when it is most nutritious. They should also consider the consistent variation in forage production from season to season and vary the stock numbers and grazing time accordingly.

Livestock graze selectively. They seek the more palatable and nutritious plants. If grazing is not controlled, the desirable plants will be eliminated and less desirable plants will increase. Pasture rotation, periodic deferment of grazing, and a good fertilization program will help maintain the desirable forage plants.

Weeds can be controlled by applying chemicals, by clipping or mowing, or by controlled grazing.

Carefully controlled grazing of newly seeded pasture is necessary to prevent destruction of the seedlings. During the first year it is desirable to allow bunch grass to produce a seed crop.

Stockwater ponds and troughs, properly located and constructed, help to control grazing (fig. 15). The ponds should be lined with impervious material to prevent seepage.

Most pasture eventually needs reseeding, depending on the kind of plants and management.

Establishing pasture is expensive. If pasture is to be seeded, the native rain-forest vegetation is bulldozed (fig. 16) and a seedbed is prepared. If preparing a seedbed is impractical, pasture can be established by controlling the existing vegetation. Chain dragging, brush raking, controlled burning, and applying chemicals are methods of controlling vegetation. On shallow soils over Aa or pahoehoe lava, the surface layer of organic matter should not be removed. Establishing pasture on extremely stony soils is difficult, because seeding, fertilizing, and controlling weeds and brush must be done by hand or by aerial methods. Stony soils are placed in the same management groups as nonstony soils, however, because the adapted pasture

[2] T. A. Bown, plant materials specialist, SCS, assisted in preparing this section.

Figure 13.—Macadamia nut tree growing in fragmental Aa lava.

plants and the methods of maintaining the pasture are the same.

Nitrogen or a nitrogen-phosphorus fertilizer is generally necessary to establish grasses. Phosphorus or a combination of phosphorus and lime is usually necessary to establish a grass-legume pasture. These should also be applied periodically to maintain yields. The application rate and timing depend on the kind of pasture plants, the soil, the climate, and the season of use.

The best planting stock available should be used for seeding pasture. Clean seed that has a high percentage of germination insures a good stand. Legumes should be inoculated with the proper rhizobium.

All of the present improved varieties of pasture plants on the island have been introduced. In the following paragraphs some improved grasses and legumes are discussed.

Improved grasses and legumes.—Koa haole (*Leucaena leucocephala*) is a deep-rooted, leguminous, long-lived shrub or small tree. It is adapted to areas that receive 25 to 60 inches of rainfall annually and are at an elevation from sea level to 1,500 feet. Koa haole is established from seed. For best results it should be mechanically planted in a prepared seedbed. It can be planted with guineagrass or green panicgrass, and it should be managed according to the growth cycle of the companion grass.

Figure 14.—Young coffee tree in bloom on Kiloa extremely stony muck, 6 to 20 percent slopes.

Big trefoil (*Lotus uliginosus*) is a long-lived, semi-prostrate legume that produces rhizomes and a large fibrous root system. It has a weak, succulent stem that roots at the leaf axis. The stem grows to a length of more than 36 inches. This legume is adapted to areas that receive more than 60 inches of rainfall annually and are at an elevation above 1,000 feet. It grows in open sunlight or partial shade. It can be established from seed or sprigs and can be planted with kikuyugrass or pangolagrass. Big trefoil has a regrowth cycle of 30 days during the warmer months and 45 days during the cooler months. It can withstand grazing to a 2-inch stubble if the grazing is rotated.

Intortum (*Desmodium intortum*) is a long-lived legume that has a long, decumbent stem. The stem sometimes roots at the leaf axis and forms new plants. Intortum is adapted to areas that receive 60 to 120 inches of rainfall annually and are at an elevation from sea level to 3,000 feet. It can be established from seed or sprigs. For best results the seed should be mechanically planted in rows in a prepared seedbed. This legume is generally planted with pangolagrass but is managed according to its own growth cycle. When the leaves have been stripped from the stems, cattle should be removed from the pasture and the intortum allowed to regrow. The regrowth cycle is about 60 days in summer and 90 days in winter.

Kikuyugrass (*Pennisetum clandestinum*) is a long-lived, deep-rooted, sod-forming grass that spreads by stolons and forms a dense turf. This is an excellent grass for pasture and for controlling erosion. It is adapted to all elevations that receive 40 to 80 inches of rainfall annually. Kikuyugrass is established from sprigs. It has a regrowth cycle of 30 days during the warmer months and 45 days during the cooler months. It can be grazed to a 2-inch stubble.

Pangolagrass (*Digitaria decumbens*) is a long-lived grass that grows 2 to 3 feet tall and produces long stolons that root at the nodes and form an open turf. It is a good forage producer and provides excellent ground cover that helps control erosion. This grass is adapted to areas that receive 60 to 120 inches of rainfall annually and are at an elevation from sea level to 3,000 feet. Pangolagrass does not produce viable seed. It is propagated by sprigging. For best results the sprigs should be planted less than 2 inches deep in a prepared seedbed. Established pangolagrass has a regrowth cycle of 30 days during the warm months and 45 days in the cool months.

Guineagrass (*Panicum maximum*) is a long-lived bunch grass that grows 6 to 8 feet tall. It is adapted to areas that receive 25 to 60 inches of rainfall annually and are at an elevation from sea level to 2,000 feet. The large, fibrous root system is a good soil binder and helps control erosion. Guineagrass is easily established from seed in a prepared seedbed. Thin stands can be improved by deferred grazing that permits the growth of a seed crop. Established guineagrass pasture is ready to graze 40 to 60 days after the end of the dry season. If soil moisture is sufficient, guineagrass can be grazed on a 60-day rotation during the hot months and a 90-day rotation during the cool months. To maintain a good stand, this grass should not be grazed closer than 8 to 10 inches.

Paragrass (*Brachiaria mutica* syn. *Panicum purpurascens*) is a long-lived, sod-forming grass. It has a coarse, trailing stem that roots at the nodes. The flower stem grows as much as 6 feet tall. Paragrass is particularly adapted to poorly drained soils that are at an elevation of less than 2,000 feet. This grass is a poor seed producer and is usually propagated from sprigs. Established paragrass has a regrowth cycle of 60 days during the warmer months and 90 days during the cooler months. Locally, it is used mainly as green-chop forage.

White clover (*Trifolium repens*) is a shallow-rooted, creeping, perennial legume that has trifoliolate leaves and stolons that root at the nodes. It is adapted to areas that receive 35 to 80 inches of rainfall. It grows at an elevation from sea level to 10,000 feet but is commonly grown at 2,000 to 7,000 feet. White clover is always established from seed and should be planted in a prepared seedbed with a mechanical planter. This is an excellent pasture legume, but good management is required to keep it in the pasture mixture. It has a regrowth

Figure 15.—Stock-water pond in an improved pasture of kikuyugrass and big trefoil.

cycle of 30 days in the warm season and 45 days in the cooler months.

Dallisgrass (*Paspalum dilatatum*) is a deep-rooted, long-lived perennial semibunch grass that has short rhizomes. It is adapted to areas that receive 30 to 100 inches of rainfall annually, and it grows at an elevation from sea level to 6,000 feet. It is best established from seed in a prepared seedbed. Dallisgrass is particularly good for erosion control. It grows best during the warm season and has a regrowth cycle of about 40 days.

Cocksfoot, or orchardgrass (*Dactylis glomerata*) is a long-lived bunch grass adapted to areas that receive 40 to 100 inches of rainfall annually and are at an elevation of 3,000 to 8,000 feet. Cocksfoot has a large fibrous root system that helps control erosion. It is easily established from seed. It should be planted mechanically less than 1 inch deep in a prepared seedbed. It can be planted with a companion legume. The companion legume can be seeded as recommended or mixed and planted with the cocksfoot seed. Cocksfoot generally has a regrowth cycle of 30 days during the warmer season, but as much as 60 days during the cooler season. In drier areas the stands can be improved by deferred grazing that allows the growth of a seed crop.

Perennial ryegrass (*Lolium perenne*) is a short-lived, perennial bunch grass that forms a turf under grazing. It is adapted to areas that receive 40 to 100 inches of rainfall annually and are at an elevation of 2,500 to 7,000 feet. The plant is always established from seed and should be planted in a prepared seedbed. Perennial ryegrass has a regrowth cycle of 30 days during its most rapid growth, but it may require 45 days during cool weather.

Buffelgrass (*Cenchrus ciliare*) is a long-lived bunch grass, well suited to areas that receive 10 to 40 inches of rainfall annually and are at an elevation of less than 2,000 feet. This grass has a large, fibrous root system that helps control erosion. It is readily established from seed, and is best established by shallow seeding with a mechanical planter in a prepared seedbed. Thin stands can be improved by deferred grazing that allows a seed crop to grow. Buffelgrass is ready to graze from 21 to 30 days after rain. If enough soil moisture is available, this grass can be grazed on a 30-day rotation, but it should never be grazed closer than 2 to 3 inches.

Green panicgrass (*Panicum maximum* var. *trichoglume*) is a medium-tall (3 to 6 feet), long-lived bunch

Figure 16.—**Native rain-forest vegetation of tree fern and ohia on Papai extremely stony muck.**

grass. It is adapted to areas that receive 22 to 60 inches of rainfall annually and are at an elevation of less than 2,000 feet. This productive forage plant makes a good ground cover that helps to control erosion. It is easily established from seed. For best results it should be mechanically planted in a prepared seedbed. This grass has excellent seedling vigor and establishes faster than guineagrass. Grazing can be deferred to produce a seed crop or to provide forage during the dry season. Established green panicgrass pasture is ready to graze 30 to 40 days after the end of the dry season. It has a regrowth cycle of 30 days during the warm months and 45 days during the cool months. Green panicgrass should not be grazed closer than 4 to 6 inches.

PASTURE GROUP 1

In this group are soils of the Kawaihae series. These soils occupy leeward coastal areas in the drier parts of the island. They have a slope of 6 to 12 percent. They are at an elevation ranging from sea level to 1,500 feet and receive from 5 to 20 inches of rainfall annually, most of which occurs during the winter. The mean annual soil temperature is between 74° and 77° F.

These soils formed in volcanic ash. They are extremely stony, somewhat excessively drained, and 20 to 40 inches deep over basalt. They are moderately permeable.

Unimproved pasture consists mostly of Hawaiian piligrass, feather fingergrass, swollen fingergrass, ilima, uhaloa, zinnia, and kiawe. Kiawe trees grow in thick stands along the coastal flats and in open stands on the uplands. During the summer the main source of food along the coastal flats is the kiawe pod. Unimproved pasture produces 1,100 to 1,400 pounds of air-dry forage per acre annually. About three-fourths of the forage is produced during the rainy season. During the dry summer months, most of the annuals die and the perennials are dormant.

Forage plants for improved pasture are buffelgrass, white piligrass, and giant bermuda. Buffelgrass is particularly well adapted. It spreads rapidly and provides ground cover that helps control erosion. Improved pasture produces 1,700 to 2,600 pounds of air-dry forage per acre annually.

PASTURE GROUP 2

In this group are Fill land and soils of the Kaalualu, Mahukona, Pakini, and Puu Pa series. These soils occupy southern coastal areas of Mauna Loa and low, leeward areas of Mauna Kea and the Kohala Mountains. They have a slope of 2 to 20 percent. They are at an elevation ranging from near sea level to 2,500 feet and receive from 10 to 40 inches of rainfall annually, most of which falls during the winter. The mean annual soil temperature is between 69° and 75° F.

These soils formed in volcanic ash and basic igneous rocks. They are well drained, are moderately to rapidly permeable, and are 20 inches to more than 60 inches deep.

Unimproved pasture on these soils consists mostly of piligrass, sandbur, natal redtop, bermudagrass, ilima, cactus, klu, Japanese tea, kiawe, and fingergrass. Winter forage production is about three times that of summer production. The total annual production is about 700 to 1,300 pounds of air-dry forage per acre.

Forage plants for improved pasture on these soils are guineagrass, buffelgrass, white piligrass, giant bermudagrass, and koa haole. Improved pasture produces 1,400 to 2,600 pounds of air-dry forage per acre annually.

PASTURE GROUP 3

This group consists of soils of the Hawi, Waiaha, and Punaluu series. These soils are on coastal plains and low uplands. Their dominant slope is 0 to 20 percent. They are at an elevation ranging from near sea level to 1,200 feet and receive from 20 to 90 inches of rainfall annually. In the Kona district most of the rain falls from July through September. The mean annual soil temperature is between 72° and 75° F.

These soils formed in volcanic ash, basic igneous rock, and organic matter. They are well drained and have moderately rapid and rapid permeability. Hawi soils are more than 48 inches deep. Waiaha soils are less than 20 inches deep over pahoehoe lava. Punaluu soils, which formed in organic matter, are less than 10 inches deep over pahoehoe lava.

Unimproved pasture consists mostly of kiawe, koa haole, klu, cactus, lantana, ilima, opiuma, natal redtop, and bermudagrass. On the Hawi and Punaluu soils, about two-thirds of the forage is produced during the winter. On the Waiaha soils, four-fifths of the forage is produced during the summer. The annual production is 1,000 to 1,500 pounds of air-dry forage per acre.

Forage plants for improved pasture are buffelgrass, guineagrass, green panicgrass, and koa haole. Improved pasture produces 2,000 to 3,000 pounds of air-dry forage per acre annually.

PASTURE GROUP 4

This group consists of soils of the Kamakoa, Kamaoa, Waikaloa, and Waimea series. These soils are on the leeward side of Mauna Kea. Their dominant slope is 0 to 20 percent. They are at an elevation ranging from 1,000 to 6,000 feet and receive from 20 to 60 inches of rainfall annually, most of which falls from November through February. The mean annual soil temperature is between 59° and 69° F.

These soils formed in alluvium and volcanic ash. They are well drained or somewhat excessively drained, and are moderately to rapidly permeable. These soils are more than 30 inches deep, except for the Kamakoa soils, which are 20 to 50 inches deep over hard, consolidated sand.

Unimproved pasture consists mostly of cactus, ilima, aalii, bermudagrass, and natal redtop, and the annual production is 1,000 to 2,000 pounds of air-dry forage per acre. About two-thirds of the forage is produced during the rainy season.

Kikuyugrass, green panicgrass, buffelgrass, bermudagrass, white clover, and bur clover are adapted for improved pasture. The annual production is 3,000 to 4,000 pounds of air-dry forage per acre.

PASTURE GROUP 5

This group consists of soils of the Kohala, Naalehu, Kainaliu, and Kaimu series. These soils are on low uplands and their slope is 0 to 35 percent. They are at an elevation ranging from near sea level to 1,800 feet and receive from 35 to 60 inches of rainfall annually. Their mean annual soil temperature is between 71° and 75° F.

These soils formed in volcanic ash, basic igneous rock, and organic matter. They are well drained and have moderately rapid to rapid permeability. They are more than 36 inches deep, except for the Kainaliu and Kaimu soils. The Kainaliu soils are 20 to 40 inches deep over Aa lava. The Kaimu soils formed in organic matter and are less than 8 inches deep over fragmental Aa lava.

Unimproved pasture consists mainly of natal redtop, bermudagrass, lantana, Christmas berry, guava, Japanese tea, and bush indigo. Monkey pod, silk oak, and ohia trees are also common in some areas. Two-thirds of the forage is produced during the winter, except in the Kona area where four-fifths of the forage is produced during the summer. The annual production is 2,000 to 3,200 pounds of air-dry forage per acre.

Guineagrass, koa haole, kikuyugrass, and kaimi clover are adapted plants for improved pasture, and the annual production is 4,000 to 7,000 pounds of air-dry forage per acre per year.

PASTURE GROUP 6

Tropaquepts are the only soils in this group. These soils are on alluvial valley bottoms. Their slope is 0 to 6 percent. They are at an elevation ranging from near sea level to 500 feet and receive from 60 to 100 inches of rainfall annually. Their mean annual soil temperature is between 72° and 75° F.

These soils formed in alluvium, and they are 20 inches to more than 40 inches deep. Their dominant properties are the result of poor drainage induced by man. These soils have poor workability. They are subject to frequent flooding. The depth to the water table is less than 20 inches.

Unimproved pasture consists mostly of hilograss, honohonograss, and wetland sedges and guava and monkey

pod. These soils are on sites that have a 12-month growing season. The annual production is about 3,000 to 4,000 pounds of air-dry forage per acre.

Pangolagrass, kikuyugrass, big trefoil, and intortum are adapted plants for improved pasture. The annual production is 4,000 to 5,000 pounds of air-dry forage per acre.

PASTURE GROUP 7

This group consists of Mixed alluvial land and soils of the following series:

Ainakea	Niulii
Honuaulu	Ookala
Kona	Opihikao
Kukaiau	Paauhau
Malama	Puna
Moaula	

These soils are on low uplands. Their slope ranges from 0 to 35 percent. They are at an elevation ranging from near sea level to 3,500 feet and receive from 60 to 120 inches of rainfall annually. Most of the rainfall on the Honuaulu soils comes during the summer. The mean annual soil temperature is between 63° and 74° F.

Mixed alluvial land is forming in young alluvium and has variable properties. Kona, Malama, Opihikao, and Puna soils formed in organic matter over lava. Kona and Opihikao soils are less than 7 inches deep over pahoehoe lava. Malama and Puna soils are less than 10 inches deep over fragmental Aa lava. The other soils formed in volcanic ash and are more than 20 inches deep. They are well drained and have moderately rapid permeability.

Unimproved pasture consists of hilograss, glenwoodgrass, yellow foxtail, carpetgrass, and guava. Ohia, silk oak, eucalyptus, and kukui trees also grow on these soils. The pasture sites have a 12-month growing season. The annual production is about 3,000 to 4,000 pounds of air-dry forage per acre.

Pangolagrass, kikuyugrass, big trefoil, and intortum are adapted plants for improved pasture. The annual production is 4,000 to 5,000 pounds of air-dry forage per acre.

PASTURE GROUP 8

This group consists of soils of the Akaka, Kahua, Kehena, Piihonua, and Puaulu series. These soils are on uplands of Mauna Kea, Mauna Loa, and the Kohala Mountains. They are at an elevation ranging from 1,000 to 6,500 feet and have a slope of 0 to 20 percent. They receive from 60 to 300 inches of rainfall annually, and it is well distributed throughout the year. Their mean annual soil temperature is between 55° and 68° F. There is considerable fog and cloud cover, especially during the winter.

These soils formed in volcanic ash and have a depth ranging from 20 inches to more than 60 inches. They are well drained to somewhat poorly drained and rapidly to slowly permeable.

Unimproved pasture consists mostly of yellow foxtail, carpetgrass, ricegrass, glenwoodgrass, rattail, tarweed, and wetland sedges. Tree fern, koa, and ohia trees grow in uncleared areas. About four-fifths of the forage is produced during the summer. The annual production is 2,000 to 3,000 pounds of air-dry forage per acre.

Kikuyugrass, pangolagrass, big trefoil, white clover, and intortum are among the adapted plants for improved pasture. The annual production is 4,000 to 5,000 pounds of air-dry forage per acre.

PASTURE GROUP 9

This group consists of soils of the following series:

Alapai	Keei
Hilea	Kiloa
Hilo	Manu
Honaunau	Ohia
Honokaa	Olaa
Kaiwiki	Panaewa
Kealakekua	Papai
Keaukaha	

These soils are on uplands and have a slope range of 0 to 35 percent. They are at an elevation ranging from near sea level to 5,000 feet. They receive from 80 to 200 inches of rainfall annually, and it is well distributed throughout the year. The mean annual soil temperature is between 58° and 74° F.

These soils are moderately well drained to well drained and are rapidly permeable. Keaukaha, Keei, Kiloa, and Papai soils formed in organic matter and are not more than 10 or 12 inches deep over pahoehoe or fragmental Aa lava. The other soils formed in volcanic ash and are 20 inches to more than 60 inches deep, except for the Hilea and Panaewa soils, which are less than 20 inches.

Unimproved pasture on these soils consists mostly of californiagrass, carpetgrass, ricegrass, and honohonograss. Ohia, tree fern, waiwi, and melastome grow in uncleared areas. The pasture sites have a 12-month growing season, but the best quality of forage is produced during the summer. The annual production is 3,000 to 5,000 pounds of air-dry forage per acre.

Pangolagrass, kikuyugrass, big trefoil, and intortum are adapted plants for improved pasture (fig. 17), and the annual production is 8,000 to 14,000 pounds of air-dry forage per acre.

PASTURE GROUP 10

This group consists of soils of the Heake, Puukala, Kahaluu, Lalaau, and Puhimau series. These soils are on uplands of Mauna Loa and Hualalai and have a slope range of 0 to 20 percent. They are at an elevation ranging from 2,000 to 7,000 feet and receive from 60 to 150 inches of rainfall annually. Their mean annual soil temperature is between 55° and 65° F.

These soils are well drained and are rapidly permeable. The Heake, Puhimau, and Puukala soils formed in volcanic ash, pumice, and cinders. They are less than 20 inches deep over pahoehoe lava. The Kahaluu and Lalaau soils formed in organic matter and are less than 10 inches deep. The Kahaluu soils are over pahoehoe lava, and the Lalaau soils are over fragmental Aa lava.

Unimproved pasture consists mostly of carpetgrass, ricegrass, glenwoodgrass, puu lehua, tarweed, and wetland sedges. The main trees are tree fern, koa, mamani, and ohia. About four-fifths of the forage is produced during the summer. The annual production is 500 to 1,500 pounds of air-dry forage per acre.

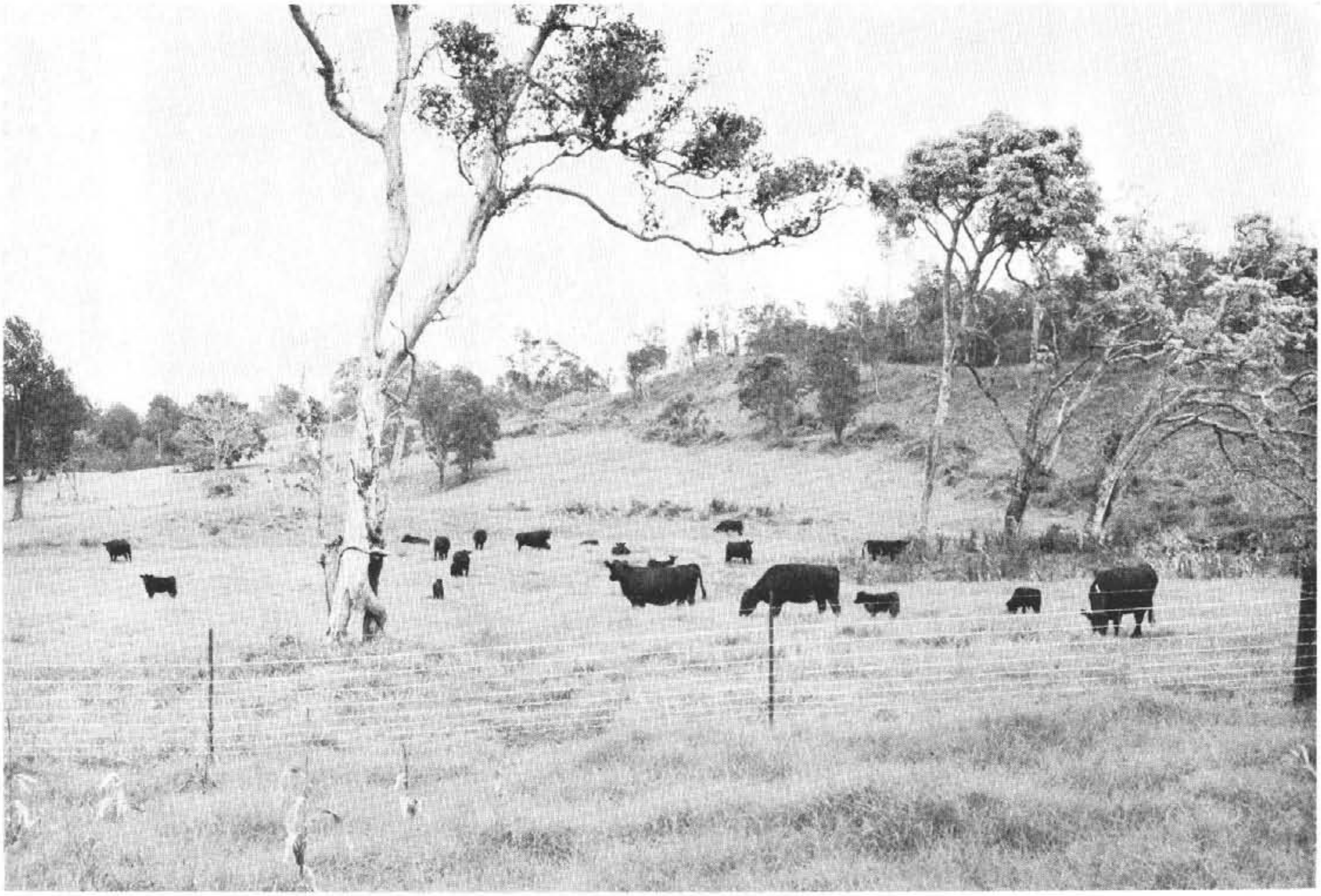


Figure 17.—**Improved pasture of kikuyugrass and big trefoil on Honokaa silty clay loam.**

Kikuyugrass, dallisgrass, orchardgrass, big trefoil, and white clover are adapted plants for improved pasture. The annual production is 1,000 to 3,000 pounds of air-dry forage per acre.

PASTURE GROUP 11

In this group are soils of the Maile, Manahaa, Punohu, and Puu Oo series. These soils are on uplands of Mauna Kea, Hualalai, and the Kohala Mountains. They have a slope of 0 to 20 percent. They are at an intermediate elevation ranging from 2,500 to 6,500 feet and receive from 50 to 100 inches of rainfall annually. Their mean annual soil temperature is between 53° and 60° F. There is considerable fog and cloud cover during the winter.

These soils formed in volcanic ash, and their depth ranges from 20 inches to more than 60 inches. They are well drained and have moderately rapid permeability.

Unimproved pasture consists of bermudagrass, rattail, sweet vernal, kukaipuaa, white clover, and alapaio fern. Koa, ohia, and tree fern grow on uncleared areas. About two-thirds of the forage is produced during spring and fall. The annual production is 4,000 to 6,000 pounds of air-dry forage per acre.

Kikuyugrass, pangolagrass, orchardgrass, ryegrass, white clover, and big trefoil are adapted plants for improved pasture, and the annual production is 8,000 to 12,000 pounds of air-dry forage per acre.

PASTURE GROUP 12

In this group are soils of the Kikoni, Palapalai, Umikoa, Kekake, and Mawae series. These soils are on uplands of Mauna Kea, Kohala, and Hualalai. They have a slope range of 0 to 20 percent. They are at an elevation ranging from 2,600 to 7,000 feet and receive from 35 to 90 inches of rainfall annually. Their mean annual soil temperature is between 52° and 66° F.

All except the Kekake and Mawae soils formed in volcanic ash and are more than 42 inches deep. The Kekake and Mawae soils formed in organic material over lava and are less than 10 inches deep. Kekake soils overlie pahoehoe lava, and the Mawae soils overlie fragmental Aa lava. The soils of this group are well drained and have moderately rapid to rapid permeability.

Unimproved pasture consists mostly of hilograss, carpetgrass, yellow foxtail, bermudagrass, and rattail and an overstory of ohia and tree fern. About two-thirds of the forage is produced during spring and fall.

Short, droughty periods and a lowering of the temperature may influence forage production. The annual production is 2,000 to 5,000 pounds of air-dry forage per acre.

Pangolagrass, kikuyugrass, orchardgrass, big trefoil, and intortum are adapted plants for improved pasture, and the annual production is 6,000 to 10,000 pounds of air-dry forage per acre.

PASTURE GROUP 13

In this group are soils of the Hanipoe, Kapapala, and Laumaia series. These soils are on the high uplands of Mauna Kea and Mauna Loa. Their slope is 0 to 20 percent. They are at an elevation ranging from 2,000 to 8,000 feet and receive from 30 to 70 inches of rainfall annually. Their mean annual soil temperature is between 50° and 61° F.

These soils formed in volcanic ash and have a depth of 36 inches to more than 60 inches. They are well drained and have moderately rapid permeability.

Unimproved pasture consists mostly of bromegrass, rattail, and kukaipuaa and an overstory of koa, ohia, and mamani. Because of the cool temperature and dry periods, forage production is seasonal. It is slightly higher during the summer. The annual production is 2,200 to 3,500 pounds of air-dry forage per acre.

Kikuyugrass, puulehua, orchardgrass, white clover, and big trefoil are adapted plants for improved pasture, and the annual production is 4,200 to 8,000 pounds of air-dry forage per acre.

PASTURE GROUP 14

In this group are soils of the Apakuie, Keekee, Kilohana, and Huikau series. These soils are on high uplands of Mauna Kea and Hualalai. Their slope is 0 to 20 percent. They are at an elevation ranging from 5,000 to 9,000 feet and receive from 15 to 40 inches of rainfall annually. Their mean annual soil temperature is between 47° and 53° F.

All except the Keekee soils formed in volcanic ash, cinders, and pumice. Keekee soils are forming in young alluvium. The soils of this group are 36 inches to more than 60 inches deep. They are well drained or somewhat excessively drained and are rapidly or very rapidly permeable.

Unimproved pasture consists mostly of puakeawe, ohelo, aalii, hardstem lovegrass, mountain pili, and sweet vernal and an overstory of koa, ohia, and mamani. Forage production is slightly higher during spring and fall. The annual production is 1,000 to 1,500 pounds of air-dry forage per acre.

Orchardgrass, alta fascue, tall meadow outgrass, velvetgrass, Parker Ranch bluestem, burclover, and black medic are prospective plants for improved pasture, and the annual production is 2,000 to 4,000 pounds of air-dry forage per acre.

Woodland [3]

In the 1930's the Civilian Conservation Corps planted trees on the Island of Hawaii, primarily for watershed protection. Many of these stands are now ready to be harvested (fig. 18). According to the "Forest Resources of Hawaii—1961" (*9*), the volume of timber on the island was about 602 million board feet, which was about 84 percent of the volume of timber in the State. The "Conservation Needs Inventory of 1967" (unpublished) lists 704,000 acres, or 28 percent of the total acreage of the island, in commercial forest.

The native forests are generally well stocked with ohia, koa, eucalyptus, and other trees. There are about 82 million board feet of robusta eucalyptus, which is used increasingly for furniture manufacturing, home construction, and other purposes (*9*).

Most of the trees that are planted are for timber, windbreaks, or watershed, but Norfolk-Island-pine is planted for Christmas trees (fig. 19), which are marketed locally and on the mainland.

Woodland conservation.—Conservation practices are needed to develop a woodland enterprise on the Island of Hawaii. Before trees can be planted, many areas need clearing to remove competing plants and prepare the soil. On shallow soils over Aa or pahoehoe lava, the organic material should be disturbed as little as possible.

Normally, seedlings are planted in spacings that range from 8 by 8 feet to 12 by 12 feet. To insure tree survival and good form, initial plantings of trees are usually closer than needed.

When the trees are 5 to 20 years of age, the stands are thinned to improve the growth and quality of the crop. Periodic commercial thinning increases income and maintains a fast growth rate of the remaining trees. The trees left for cutting are pruned.

When the stand has reached a desired size, it is harvested by clear cutting or by some type of shelterwood cutting. After the harvest, regeneration of the stand begins, and competing vegetation is removed until the seedlings are well established.

Proper construction of access roads and control of erosion are important. Roads should be constructed on grades of less than 12 percent and protected from erosion by water bars, culverts, and ditches.

Woodland groups.—The soils of the island have been placed in woodland groups on the basis of adapted species of trees, estimated annual productivity per acre, seedling mortality, plant competition, equipment limitations, erosion hazard, and windthrow hazard.

Adapted species are trees that are best suited for planting or for favoring in existing stands. On the Island of Hawaii, most of the trees that are grown commercially are exotics that have been introduced. Ohia and koa are the main native trees that are satisfactory for commercial production.

Estimated annual productivity per acre is the estimated annual production of board feet per acre measured according to the international ¼-inch rule. At present there are no site or yield tables for any species of trees grown in Hawaii, but many stands of trees that have a known age have been measured and yields have been estimated on the basis of a harvesting cycle of 30 to 60 years, using robusta eucalyptus as a standard. One reason for the wide range in productivity within a group is the variation in growth rate between species of trees.

Seedling mortality is the mortality of naturally occurring or planted seedlings, as influenced by soil, topography, and climate. The rating is *slight* if the expected

[3] JOHN HULTGREN, woodland conservationist, Soil Conservation Service, assisted in preparing this section.

Figure 18.—**Eucalyptus trees approximately 25 years old on Honokaa silty clay loam.**

mortality is less than 25 percent, *moderate* if it is between 25 and 50 percent, and *severe* if it is greater than 50 percent.

Plant competition is the invasion or growth of undesirable plants. *Slight* competition does not prevent natural regeneration or the growth of planted seedlings. *Moderate* competition delays but does not prevent the eventual establishment of adequately stocked stands. *Severe* competition prevents establishment of stands unless the site is intensively prepared and weeded.

Equipment limitations are limitations imposed by the characteristics of the soils that restrict or prevent the use of equipment in tending and harvesting trees. The limitation is *slight* if it does not restrict the kind of equipment or the time of year in which it can be used. The limitation is *moderate* if the use of equipment is moderately restricted by slope, stones, seasonal wetness, or physical characteristics of the soils. The limitation is *severe* if special equipment is needed and its use is restricted by slope, stones, wetness, or soil characteristics.

Erosion hazard depends on slope, soil stability, permeability, water-holding capacity, and extent of past erosion. Erosion in woodland seldom occurs until vegetation is disturbed or destroyed by fire or by excessive grazing, logging, or road building. The hazard is *slight* if there are only minor problems, *moderate* if some control measures are necessary, and *severe* if intensive control measures and special equipment are needed.

Windthrow hazard is the possibility of trees being blown over by wind. The hazard is *slight* if trees are not expected to be blown down by commonly occurring winds, *moderate* if some trees growing on wet or shallow soil are likely to be blown down by high wind, and *severe* if most of the trees growing in a stand on wet or shallow soil are expected to be blown down by moderate or high wind.

WOODLAND GROUP 1

This group consists of well-drained and somewhat excessively drained very fine sandy loams that formed in volcanic ash. These soils have a slope range of 0 to 20 percent. They are at an elevation of 1,000 to 6,000 feet and receive 20 to 60 inches of rainfall annually. The mean annual soil temperature is between 59° and 69° F.

Loblolly pine, slash pine, and gray ironback eucalyptus are the adapted species. The estimated annual production is 100 to 200 board feet per acre. Seedling mortality is moderate to severe. Plant competition is slight from bermudagrass, aali, and cactus. The equipment limitation is slight except in stony areas. The erosion hazard is slight to moderate, and the windthrow hazard is slight.

WOODLAND GROUP 2

This group consists of well-drained silty clay loams that formed in volcanic ash. These soils have a slope range of 0 to 35 percent. They receive from 35 to 60 inches of rainfall annually and are at an elevation of

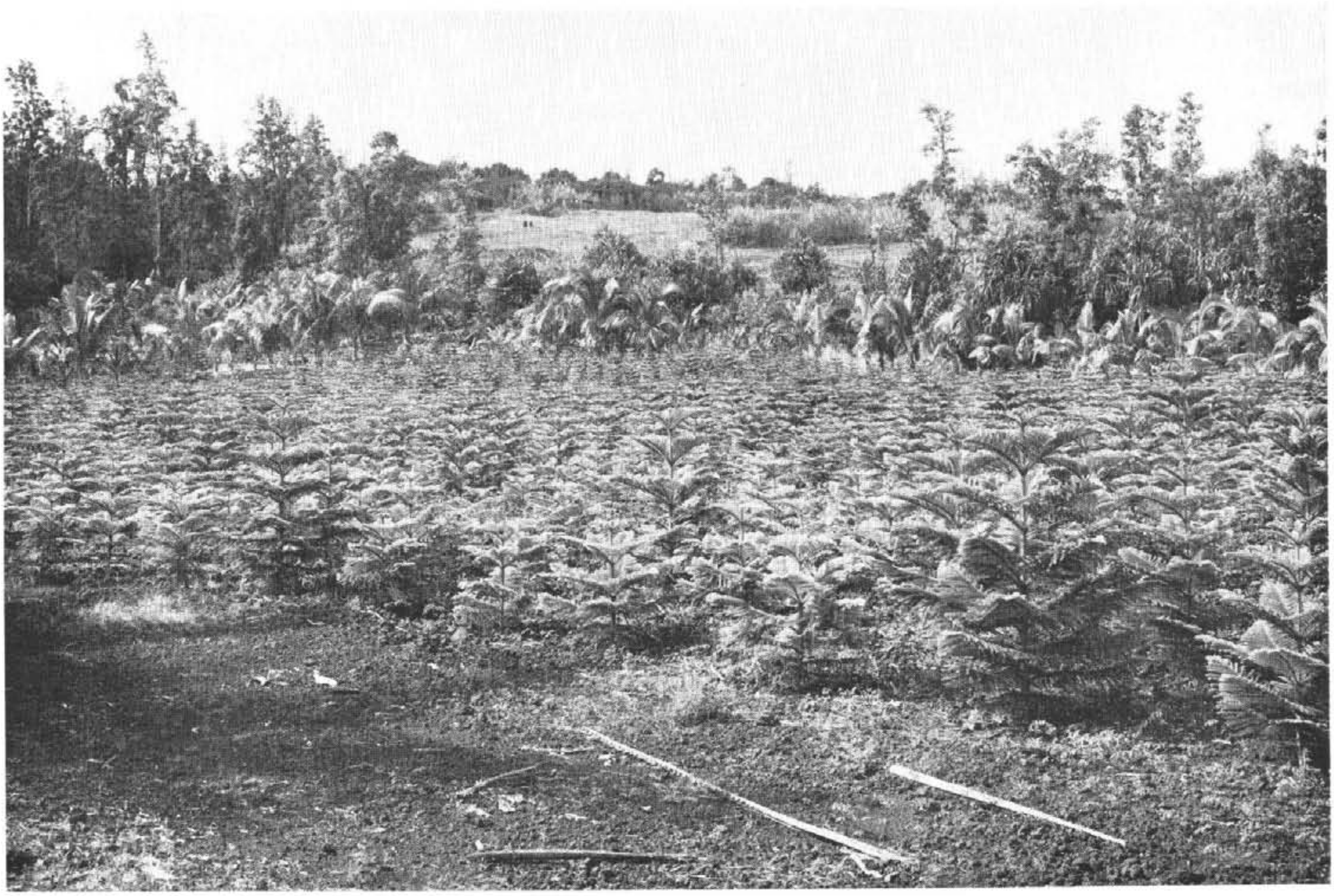


Figure 19.—Norfolk-Island-pine, planted for Christmas trees, on Malama extremely stony muck.

750 to 1,800 feet. Their mean annual soil temperature is between 71° and 75° F.

The adapted species are saligna eucalyptus, gray ironbark eucalyptus, red ironbark eucalyptus, silk oak, and Norfolk-Island-pine. The estimated annual production is 200 to 400 board feet per acre. Seedling mortality is moderate. Plant competition is moderate from bermudagrass, kikuyugrass, hilograss, and rattail. The equipment limitation is slight to moderate, the windthrow hazard is slight, and the erosion hazard is slight to severe.

WOODLAND GROUP 3

This group consists of moderately deep, poorly drained soils that formed in recent alluvium. These soils have a slope range of 0 to 3 percent. They receive from 60 to 100 inches of rainfall annually and are at an elevation of 0 to 500 feet. The mean annual soil temperature is between 70° and 76° F.

Monkey pod, robusta eucalyptus, saligna eucalyptus, and albizzia are the adapted species on these soils. The estimated annual production is 500 to 800 board feet per acre. Seedling mortality is slight. Plant competition is moderate from hilograss, californiagrass, guava, and ferns. The equipment limitation and windthrow hazard are severe. The erosion hazard is slight. These soils are subject to frequent flooding.

WOODLAND GROUP 4

This group consists of well-drained silty clays that formed in residuum from basic igneous rock. These soils have a slope range of 0 to 35 percent. They receive from 40 to 60 inches of rainfall annually and are at an elevation ranging from sea level to 1,500 feet. The mean annual soil temperature is between 72° and 74° F.

Norfolk-Island-pine, robusta eucalyptus, silk oak, and monkey pod are the adapted species. Estimated annual production is 200 to 400 board feet per acre. Seedling mortality is moderate to severe. Plant competition is moderate from bermudagrass. The equipment limitation is slight to moderate, the erosion hazard is slight to severe, and the windthrow hazard is slight.

WOODLAND GROUP 5

This group consists of well-drained silty clay loams that formed in volcanic ash. These soils have a slope range of 0 to 35 percent. They receive from 60 to 120 inches of rainfall annually and are at an elevation ranging from near sea level to 2,500 feet. The mean annual soil temperature is between 65° and 74° F.

Saligna and robusta eucalyptus, Australian toon, Queensland maple, monkey pod, silk oak, Norfolk-Island-pine, and albizzia are the adapted species on these soils. The estimated annual production is 500 to 800 feet per acre. Seedling mortality is slight. Plant competition is moderate from hilograss, californiagrass, guava, Christmas berry, and kikuyugrass. The equipment limitation is slight to moderate, the windthrow hazard is slight, and the erosion hazard is slight to severe.

WOODLAND GROUP 6

This group consists of well-drained to somewhat poorly drained soils that formed in volcanic ash and have a silt loam or silty clay loam texture. These soils have a slope range of 0 to 20 percent and are more than 20 inches deep. They are on uplands at an elevation ranging from 1,000 to 6,500 feet and receive from 90 to 300 inches of rainfall annually. The mean annual soil temperature is between 55° and 68° F.

Robusta eucalyptus, Nepal alder, tropical ash, and the native ohia are the adapted species. The estimated annual production is 500 to 900 board feet per acre. Seedling mortality is slight. Plant competition is severe from tree fern, false staghorn fern, melabar melastome, downy myrtle, and kikuyugrass. The equipment limitation is severe because of the low bearing capacity of these soils. The erosion hazard is slight to moderate, and the windthrow hazard is slight.

WOODLAND GROUP 7

This group consists of well drained and moderately well drained silt loams and silty clay loams that formed in volcanic ash. These soils have a slope range of 0 to 35 percent. They are at an elevation ranging from near sea level to 5,000 feet and receive from 80 to 200 inches of rainfall annually. Their mean annual soil temperature is between 58° and 74° F.

The adapted species are saligna and robusta eucalyptus, Nepal alder, Norfolk-Island-pine, Australian toon, Queensland maple, tropical ash, blackwood, sugi, redwood, and monkey pod. Ohia and koa are native trees that are well adapted. The estimated annual production is 700 to 1,000 board feet per acre. Seedling mortality is slight. Plant competition is severe from tree fern, false staghorn fern, melabar melastome, downy myrtle, and kikuyugrass. The equipment limitation is moderate to severe. The erosion hazard is slight to severe, and the windthrow hazard is slight.

WOODLAND GROUP 8

This group consists of well-drained silt loams that formed in volcanic ash. These soils have a slope range of 0 to 20 percent. They are at an elevation of 2,500 to 6,500 feet and receive from 50 to 100 inches of rainfall annually. Their mean annual soil temperature is between 53° and 60° F.

The adapted species are saligna and robusta eucalyptus, Australian toon, Queensland maple, tropical ash, slash pine, redwood, sugi, and the native ohia and koa. The estimated annual production is 500 to 800 board feet per acre. Seedling mortality is slight. Plant competition is slight, except where kikuyugrass grows. The equipment limitation is slight, except on the very stony soils where it is moderate. The erosion hazard is slight to moderate, and the windthrow hazard is slight.

WOODLAND GROUP 9

This group consists of well-drained very fine sandy loams, silt loams, and silty clay loams that formed in volcanic ash. These soils have a slope range of 0 to 20 percent. They receive from 35 to 90 inches of rainfall annually and are at an elevation of 2,600 to 5,000 feet. Their mean annual soil temperature is between 55° and 66° F.

The adapted species are saligna and robusta eucalyptus, Australian toon, Queensland maple, tropical ash, and loblolly and slash pine. The estimated annual production is 500 to 700 board feet per acre. Seedling mortality is slight. Plant competition is severe from kikuyugrass and paspalum. The equipment limitation is slight, the erosion hazard is slight to moderate, and the windthrow hazard is slight.

WOODLAND GROUP 10

This group consists of well-drained loams and silt loams that formed in volcanic ash. These soils have a slope range of 0 to 20 percent. They receive from 30 to 70 inches of rainfall annually and are at an elevation of 2,000 to 8,000 feet. Their mean annual soil temperature is between 52° and 61° F.

The adapted species are saligna eucalyptus, sugi, tropical ash, loblolly pine, slash pine, and the native koa and ohia. The estimated annual production is 400 to 600 board feet per acre. Seedling mortality is slight. Plant competition is moderate from alapaio fern, dallisgrass, and kikuyugrass. The equipment limitation is slight, except on very stony soils where it is moderate. The erosion hazard is slight to moderate, and the windthrow hazard is slight.

WOODLAND GROUP 11

In this group are shallow sandy loams and silt loams that formed in volcanic ash and pumice over pahoehoe lava. These soils are only 10 to 20 inches deep. They have a slope range of 0 to 20 percent. They receive from 60 to 125 inches of rainfall annually and are at an elevation of 2,000 to 4,000 feet. Their mean annual soil temperature is between 59° and 61° F.

Saligna eucalyptus, blackwood, sugi, tropical ash, and Nepal alder are the adapted species. The estimated annual production is 200 to 500 board feet per acre. Seedling mortality is slight. Plant competition is slight to moderate from tree fern and kikuyugrass. The equipment limitation is slight to moderate. The erosion hazard is slight to moderate, and the windthrow hazard is severe.

WOODLAND GROUP 12

This group consists of shallow silty clay loams that formed in volcanic ash and are only 10 to 20 inches deep over pahoehoe lava. These soils have a slope range of 0 to 20 percent. They receive from 100 to 200 inches of rainfall annually and are at an elevation of 300 to 2,000 feet. Their mean annual soil temperature is between 65° and 74° F.

Robusta and saligna eucalyptus, sugi, Australian toon, and the native ohia and koa are the adapted

species on these soils. The estimated annual production is 500 to 900 board feet per acre. Seedling mortality is slight. Plant competition is slight to moderate from tree fern, hilograss, californiagrass and melabar melastome. The equipment limitation is moderate, the erosion hazard is slight, and the windthrow hazard is moderate to severe.

WOODLAND GROUP 13

In this group are mucky soils that formed in organic matter and are less than 10 inches deep over Aa lava. These soils have a slope range of 0 to 20 percent. They receive from 60 to 150 inches of rainfall annually and are at an elevation ranging from near sea level to 4,000 feet. Their mean annual soil temperature is between 63° and 75° F.

Saligna and robusta eucalyptus, blackwood, Queensland maple, Australian toon, and the native ohia are the adapted species. Estimated annual production is 700 to 1,000 board feet per acre. Seedling mortality is slight. Plant competition is severe from tree fern, guava, and kikuyugrass. The equipment limitation is severe. The erosion and windthrow hazards are slight.

WOODLAND GROUP 14

In this group are mucky soils that formed in organic matter and are less than 12 inches thick over Aa lava. These soils have a slope range of 0 to 20 percent. They receive from 50 inches to more than 150 inches annually and are at an elevation of 3,500 to 7,000 feet. Their mean annual soil temperature is between 53° and 59° F.

Saligna and robusta eucalyptus, tropical ash, blackwood, redwood, sugi, and the native ohia and koa are the adapted species. The estimated annual production is 500 to 700 board feet per acre. Seedling mortality is slight. Plant competition is moderate from tree fern and kikuyugrass. The equipment limitation is severe. The erosion hazard and windthrow hazard are slight.

WOODLAND GROUP 15

This group consists of well-drained silt loams that formed in volcanic ash and are 10 to 20 inches deep over pahoehoe lava. These soils have a slope range of 0 to 20 percent. They receive from 20 to 40 inches of rainfall annually and are at an elevation ranging from near sea level to 1,000 feet. Their mean annual soil temperature is between 72° and 74° F.

Silk oak, mango, and monkey pod are the adapted species. The estimated annual production is 100 to 300 board feet per acre. Seedling mortality is severe. Plant competition is severe from guineagrass. The equipment limitation and the erosion hazard are slight to moderate. The windthrow hazard is severe.

WOODLAND GROUP 16

In this group are well-drained and somewhat excessively drained very fine sandy loams, loamy sands, and loamy fine sands that formed in volcanic ash or cinders. These soils have a slope range of 0 to 20 percent. They receive from 15 to 40 inches of rainfall annually and are at an elevation of 5,000 to 9,000 feet. Their mean annual soil temperature is between 47° and 53° F.

Loblolly and slash pine and gray ironbark eucalyptus are the adapted species. The estimated annual production is 100 to 200 board feet per acre. Seedling mortality is moderate to severe. Plant competition is slight from mamani, naio, aalii, and lovegrass. The equipment limitation is slight to moderate, the erosion hazard is slight to severe, and the windthrow hazard is slight.

Wildlife

Various kinds of wildlife thrive on the island, from the arid coastal plains to the very humid rain forests on the mountain slopes. Nearly all the big game and the upland game birds were introduced. The first pigs were brought in by the early Polynesians as a source of food. Goats were introduced by Captain Cook in 1778. Captain Vancouver brought sheep and cattle as gifts to the royalty in 1794. A tabu was placed on them, however, and they went wild in the forest (*23*).

Since 1920 many kinds of birds have been introduced for hunting, for control of insects, and for esthetic value. Birds that have been brought in primarily for hunting are the Chinese ring-necked pheasant, California valley quail, Japanese quail, Indian chukar partridge, barred dove, and lace-necked dove. The Rio-Grande turkey, Reeves' pheasant, Barbary partridge, Gambel's quail, and francolin partridge have been introduced lately by the State Fish and Game Division of Hawaii (*14*).

Bass and bluegill are stocked in some reservoirs in Kohala.

Wild pigs are found from sea level to high up in the mountains. Goats are common on rocky areas throughout the island. Feral sheep are concentrated on the high slopes of Mauna Kea and Mauna Loa.

The hunting season extends year round for sheep, goats, and pigs. The game-bird season usually opens during the beginning of November and closes in the middle of January. Bow and arrow hunting for sheep and pigs is open all year in certain areas.

There are five public hunting grounds, or game management areas, on the Island of Hawaii. These are located within four soil associations described in the "General Soil Map" section of this publicaton.

The *Puako game area* is an arid habitat in the Kawaihae soil association. The vegetation consists of kiawe, ilima, and piligrass. Pheasants, lace-necked and barred doves, and Gambel's quail are hunted here.

The *Mauna Loa game area* is in the Saddle overlapping the Kekake-Keei-Kiloa and the Lava flows soil associations. The vegetation in the Kekake-Keei-Kiloa soil association consists of ohia and tree fern forest. The Lava flows association has a sparse vegetation of ohelo berry, aalii, and mamani. Wildlife hunted in this area include goats, feral sheep, wild pigs, pheasants, California quail, Japanese quail, chukar partridge, and doves.

The *Mauna Kea game area* is within the boundaries of the Mauna Kea State Forest. The area extends from an elevation of about 6,000 feet to the top of the mountain. It is in the Lava flows soil association. The vegetation consists of ohelo berry, aalii, naio, and mamani trees. Wild pigs, goats, feral sheep, pheasants, quail, chukar partridge, doves, and pigeons live in this area.

The *Horse Pasture game area* occurs within the Waimea-Kikoni-Naalehu soil association, which has a vegetative cover of grass and brush. This area is open to upland game bird hunting.

424-785—73——6

The *Pohakuloa game area* is a semi-arid alluvial flat in the Saddle between Mauna Kea and Mauna Loa. All kinds of birds and big game common on the island are found in limited numbers.

Management of the Soils for Engineering [4]

This section provides information of special interest to engineers, builders, farmers, and others who use soil as structural material or as foundation material upon which structures are built. Among the soil properties most important in engineering are permeability, shear strength, shrink-swell potential, available water capacity, and reaction.

Information concerning these and related soil properties are in tables 2, 3, and 4. The data and interpretations in these tables can be used in:

1. Planning and designing agricultural drainage systems, farm ponds, irrigation systems, and other structures for controlling water and conserving soil.
2. Selecting potential locations for highways, airports, pipelines, and underground cables.
3. Locating probable sources of sand, gravel, or rock suitable for use as construction material.
4. Selecting potential industrial, commercial, residential, and recreational areas.

The engineering data and interpretations reported here do not eliminate the need for onsite sampling and testing, especially on sites that are to support heavy loads or where the excavations are deeper than the soil layers reported here. Even in these situations, however, the engineering data and the soil maps are useful in planning more detailed field investigations and for indicating the kinds of problems that can be expected.

Some of the terms used in this publication have special meanings in soil science that do not correspond with the meanings of the same terms in engineering. These terms are defined in the Glossary according to their meaning in soil science. For additional information, engineers may want to refer to the section describing the soils and the section on classification and formation of the soils.

Engineering classification systems

The two systems most commonly used in classifying soils for engineering are the AASHO system (*2*), used by the American Association of State Highway Officials, and the Unified system (*22*), used by the Soil Conservation Service, the Department of Defense, and others.

The soils of this survey are classified according to the Unified Soil Classification System. This system is based on particle-size distribution, plasticity, liquid limit, and organic-matter content. It divides soils into three major groups—coarse grained (eight classes), fine grained (six classes), and organic.

The soils have not been classified in accordance with the AASHO system, which has limited value in classifying the engineering properties of Hawaiian soils. Most of these soils are very fine grained and are in groups A–6 or A–7, but they do not exhibit engineering properties associated with temperate-region soils in these groups.

Estimated properties of the soils

Table 2 provides estimates of soil properties that are important in engineering. The estimates are based on field classifications and descriptions, on physical and chemical tests of selected representative samples, on test data from comparable soils in adjacent areas, and on experience in working with the individual kind of soil in the survey area.

The estimates are given for the soil profile, which is divided into layers that have signficantly different engineering properties. The thickness of these layers and the depth from the surface are shown.

The USDA texture is the apparent field texture. By standards of mechanical analysis, most soils described in this publication are clay.

The *Unified classification* group symbol is shown for each significant layer. If the classification is borderline between two groups, a hyphen is used between the two symbols, such as "ML-CL." Engineering properties of Hawaiian soils placed in ML, MH, and CL groups may be significantly different from those of other soils in temperate regions in these groups. Hawaiian soils exhibit a higher shear strength and a lower shrink-swell volume with change in moisture content. The difference in these properties is apparently related to the very fine particle size, the microstructure, and the high aggregate stability.

Permeability relates only to movement of water downward through undisturbed soil. It does not include lateral seepage. The estimates are based on soil structure, porosity, and limited permeabilty tests on undisturbed cores. Flowpans, surface crusts, and other properties resulting from use of the soils are not considered.

Available water capacity is the amount of water available to plants. It is the water retained in the soil between the wilting point and field capacity. These estimates are based on extensive laboratory tests, field experience, and soil properties. Estimates of available water capacity are given only for the Hawi, Kikoni, Kohala, Mahukona, Paauhau, and Waimea soils, which are now irrigated.

Reaction is the degree of acidity or alkalinity of a soil, expressed as a pH value. The pH value and relative terms used to describe soil reaction are explained in the Glossary.

Shrink-swell potential is an indication of the volume change to be expected of the soil material with changes in moisture content. A high shrink-swell potential indicates hazards to the maintenance of structures built in, on, or with such soil material. Generally, soils classified as CH have a high shrink-swell potential, and those classified as ML and SP have a low shrink-swell potential. Many of the soils classified as OH are in areas of high rainfall and are wet throughout the year. These soils exhibit a high shrink and a low swell potential when used in a dry environment.

Corrosivity indicates the potential danger to uncoated metal or concrete structures through chemical action that dissolves or weakens the structural material. Some

[4] HARLAN G. COLLINS, irrigation engineer; and HUGO T. SHOGREN, State conservation engineer, Soil Conservation Service, assisted in preparing this section.

structural materials corrode when buried in soil, and they corrode more rapidly in some soils than in others. Extensive installations that intersect soil boundaries or soil horizons are more likely to be damaged by corrosion than are installations entirely in one kind of soil or soil horizon.

Engineering interpretations

Table 3 interprets the soil properties in terms of suitability or limitations for specific farming and engineering uses. These interpretations are based on the estimates shown in table 2, on test data in table 4, and on field experience.

Sources of gravel are not indicated in table 3. The best sources are Aa lava, crushed hard rock, or coral.

Engineering interpretations have not been given for agricultural drainage and irrigation. Drainage is not needed or not applicable on most of the soils of this survey area. Only the Hawi, Kikoni, Kohala, Mahukona, Paauhau, and Waimea soils are irrigated. These soils have moderate or rapid intake rate and moderate or high available water capacity.

Topsoil is a fertile soil or soil material, ordinarily rich in organic matter, used as a topdressing for lawns, gardens, roadbanks, and the like. Soils that have low natural fertility are rated according to their response to fertilization.

Road fill is material used to build embankments. The ratings indicate performance of soil material moved from borrow areas for these purposes.

Highway location is influenced by features of the undisturbed soil that affect construction and maintenance of highways.

Farm pond reservoir areas are affected mainly by soil features that control the seepage of water.

Farm pond embankments serve as dams. They are affected by features of both the subsoil and substratum that are important in the construction of embankments.

Foundations for low buildings are affected chiefly by features of the undisturbed soil that influence its capacity to support low buildings that have normal foundation loads. Specific values of bearing strength are not assigned.

Septic tank filter fields are affected mainly by permeability, slope, depth to water table and to bedrock, and susceptibility to flooding.

Engineering test data

Table 4 contains the results of engineering tests performed by the Bureau of Public Roads and Soil Conservation Service on samples of selected soil series. The table shows the location of the samples, the depth of sampling, and the results of tests to determine liquid limit and plasticity index.

Liquid limit and plasticity index indicate the effect of water on the strength and consistence of soil material. As the moisture content of a clayey soil is increased from a dry state, the material changes from a semisolid to a plastic state. If the moisture content is further increased, the material changes from a plastic to a liquid state. The plastic limit is the moisture content at which the soil material passes from a semisolid to a plastic state. The liquid limit is the moisture content at which the material changes from a plastic to a liquid state. The plasticity index is the numerical difference between the liquid limit and the plastic limit. It indicates the range of moisture content within which a soil material is plastic.

Classification of the Soils [5]

The Island of Hawaii has a variety of soils as a result of extremes in the factors that are active in soil genesis: climate, vegetation, parent material, relief, drainage, and time. Annual rainfall ranges from 10 inches on the dry leeward coast to more than 300 inches in the wet windward mountain areas. Elevation ranges from sea level to more than 13,000 feet. The average annual temperature at sea level is about 75° F. and decreases on the average about 3° F. for each increase of 1,000 feet in elevation. The mean temperature difference between the coldest and warmest month does not exceed 9° F. at any location on record. Parent material ranges in age from Pliocene to present. It is dominantly volcanic ash and basic igneous rock. These differences in age, parent material, relief, and climate coincide closely with the patterns of vegetation and soil (*7*). Consequently, the morphology of each soil reflects the combined effects of the genetic factors responsible for its development.

Soils are classified according to their observable and measurable properties. The properties chosen are primarily those that permit the grouping of soils that are genetically similar. Soil classification enables us to understand the pattern of soils and the ways in which they relate to each other.

The scheme of classification used in this survey was developed in the early sixties (*12*). It was adopted for general use by the National Cooperative Soil Survey in 1965 and supplemented in March 1967 and September 1968 (*20*). It replaces a system, adopted in 1938 (*18*) and later revised (*17*), that was used in the Soil Survey of the Territory of Hawaii by Cline and others (*5*). The current system incorporates knowledge gained through research over the last 25 years and is much more precise and more complex than the older system. It is under continual study. Readers interested in the development of the system should refer to the latest literature available (*20*).

The current system of classification has six categories. Beginning with the most inclusive, these categories are the order, the suborder, the great group, the subgroup, the family, and the series. The placement of some soil series in the current system of classification, particularly in families, may change as more precise information becomes available.

Table 5 (p. 101) shows, according to the current system, the classification of each soil series on the island by family and by subgroup, which also reflects the great group. It also shows one category—the great soil group—of the 1938 system.

---

[5] By LESLIE D. SWINDALE, associate director, Hawaii Agricultural Experiment Station, and professor of soil science, University of Hawaii; and by HARRY H. SATO, Soil Conservation Service.

TABLE 2.—*Estimated engineering*

[Blank space indicates data are not available or are not applicable. An asterisk in the first column indicates that at least one mapping and for this reason it is necessary to follow carefully the instructions for

Soil series and map symbols	Depth to bedrock	Depth from surface	Classification: Dominant USDA texture	Classification: Unified
	Feet	*Inches*		
Ainakea: AaC, AaD, AaE	2–3½	0–30 30	Silty clay loam Weathered basalt.	OH–MH
Akaka: AkC, AkD, rAK	3½–7	0–72	Silty clay loam	OH
Alapai: AlC, AlD, AlE, ApD	3½–6	0–74	Silty clay loam (ApD; extremely stony)	OH
*Amalu: rAM, rAR[3] For Rough broken land part of rAR, see Rough broken land.	1–2	7–0 0–20 20	Muck Silty clay loam Pahoehoe lava.	Pt OH
Apakuie: AFD, ASD	2½–5	0–30 30–60	Very fine sandy loam (ASD; very stony) Loamy sand	ML SM
Beaches: BH	(4)		Sand	SP–SM
Cinder land: rCL	(4)		Cinders	
Fill land: FL. Properties are variable.				
Hanipoe: HCD, HDD, HFD	1½–6	0–60	Silt loam (HCD; very stony; HFD; very rocky).	MH–OH
Hawi: HaA, HaC, HeC	4–6	0–68	Silty clay (HeC; extremely stony)	MH
Heake: HHC, HKC	1–2	0–12 12–17 17	Sandy loam and fine sand Pumice Pahoehoe lava.	SM
Hilea: HIC	1–1½	0–19 19	Silty clay loam Pahoehoe lava.	OH
Hilo: HoC, HoD, HoE	6–8	0–60	Silty clay loam	OH
Honaunau: HND, HRD	1½–2½	0–26 26	Silt loam and silty clay loam (HRD: extremely rocky). Pahoehoe lava.	OH
Honokaa: HsC, HsD, HsE, HTD, HTE	3½–6	0–65	Silty clay loam	OH
Honuaulu: HUD, HVD	1½–3½	0–37 37	Silty clay loam (HUD: very stony; HVD: extremely stony). Fragmental Aa lava.	OH–MH
Huikau: rHID, rHID2, rHLD	2½–5	0–17 17–60	Loamy sand (rHLD: extremely stony) Sand, cinders, and stones	SM GP
*Hydrandepts: rHP For Tropofolist part, see Tropofolists.	3½–6		Silty clay loam	OH
Kaalualu: KBC	1½–2½	0–5 5–24 24	Sandy loam (extremely stony) Silt loam Fragmental Aa lava.	SM ML
Kahaluu: rKAD	0–1	5–0 0–10	Muck (extremely rocky) Pahoehoe lava.	Pt
Kahua: KCD	3½–5	0–60	Silty clay loam	OH
Kaimu: rKED	0–1	3–0 0–20	Peat (extremely stony) Fragmental Aa lava.	Pt
Kainaliu: KDD, KEC	1½–3½	0–26 26	Silty clay loam and silt loam (KDD: very stony; KEC: extremely stony). Fragmental Aa lava.	MH

See footnotes at end of table.

properties of the soils

unit in this series is made up of two or more kinds of soil. The soils in such mapping units may have different properties and limitations, referring to other series that appear in the first column of this table]

Permeability	Available water capacity [1]	Reaction	Shrink-swell potential	Corrosivity	
				Uncoated steel	Concrete
Inches per hour	*Inches per inch of soil*	*pH*			
2.0-6.3		<4.5-6.0	Moderate	Moderate	Moderate.
6.3-20		5.1-6.0	High [2]	Moderate to high	Moderate.
6.3-20		4.5-7.3	High [2]	Low	Low.
6.3-20		<4.5	High [2]	High	High.
0.06-0.20		4.5-5.0	High	High	High.
6.3-20		6.6-7.3	Low	Low	Low.
6.3-20		6.6-7.3	Low	Low	Low.
>20			Low	Low	Low.
>20			Low	Low	Low.
2.0-6.3		6.1-7.3	Low	Low	Low.
0.63-2.0	0.13-0.15	6.1-7.3	Moderate	Low	Low.
6.3-20		5.6-7.3	Low	Low	Low.
6.3-20		6.6-7.3	Low	Low	Low.
6.3-20		4.5-5.5	High [2]	High	High.
6.3-20		4.5-6.0	High [2]	Moderate	Moderate.
6.3-20		5.6-6.5	High [2]	Moderate	Moderate.
6.3-20		5.6-6.5	High [2]	Moderate	Moderate.
6.3-20		5.6-6.0	Moderate	Moderate	Moderate.
>20		6.6-7.3	Low	Low	Low.
>20		6.6-7.3	Low	Low	Low.
6.3-20		5.6-6.5	High [2]	Moderate	Moderate.
6.3-20		6.6-7.3	Low	Low	Low.
6.3-20		6.6-7.3	Low	Low	Low.
6.3-20		4.5-5.0	High [2]	High	High.
0.20-0.63		4.5-5.5	High [2]	High	High.
6.3-20		6.6-7.3	High [2]	Low	Low.
6.3-20		5.6-7.3	Low	Low	Low.

TABLE 2.—*Estimated engineering*

Soil series and map symbols	Depth to bedrock	Depth from surface	Classification	
			Dominant USDA texture	Unified
	Feet	*Inches*		
Kaiwiki: KaC, KaD, KaE	6-8	0-60	Silty clay loam	OH
Kamakoa: KGC	4-6	0-9	Very fine sandy loam and very fine sand	SM
		9-34	Sand	SW
		34-48	Very fine sandy loam	SM
Kamaoa: KIC, KJC, KKC	1½-5	0-21	Loam (KKC: extremely stony)	ML
		21-47	Silty clay loam	MH
		47-68	Silt loam	ML
Kapapala: KLC, KLD, KMD	1½-5	0-48	Loam, sand, loamy sand, and silt loam (KMD: very rocky).	ML
		48	Pahoehoe lava.	
Kawaihae: KNC, KOC	1½-3½	0-33	Silt loam and loam (KNC: extremely stony; KOC: very rocky).	ML
		33	Pahoehoe lava.	
Kealakekua: KPD, KRD, KSD	1½-4	0-31	Silty clay loam (KRD: very stony; KSD: extremely stony).	OH
		31	Pahoehoe lava.	
Keaukaha: rKFD	0-1	8-0	Muck (extremely rocky)	Pt
		0-10	Pahoehoe lava.	
Keei: rKGD	0-1	10-0	Muck (extremely rocky)	Pt
		0-10	Pahoehoe lava.	
Keekee: KTB	3½-8	0-9	Loamy sand and silt loam	SM
		9-16	Silty clay loam	ML-MH
		16-40	Sand	SM
		40-60	Loam	ML
Kehena: KVC	1½-4	0-26	Silty clay loam	OH
		26	Pahoehoe lava.	
Kekake: rKHD	4-0	4-0	Muck (extremely rocky)	Pt
		0-10	Pahoehoe lava.	
Kikoni: KfA, KXC, KYC	4-8	0-11	Very fine sandy loam (KYC: extremely stony).	ML
		11-25	Very fine sandy loam	ML
		25-50	Silt loam	ML
Kilauea: rKUC	1½-5	0-60	Sand and fine sand (extremely gravelly)	SM
Kiloa: rKXD	0-1	10-0	Muck (extremely stony)	Pt
		0-10	Fragmental Aa lava.	
Kilohana: KZD	4-8	0-42	Loamy fine sand and fine sand	SM
		42	Semiconsolidated ash and cinders.	
Kohala: KhA, KhC, KhD, KhE	3½-8	0-39	Silty clay and silty clay loam	MH
		39	Saprolite.	
Kona: rKYD	0-1	5-0	Muck (extremely rocky)	Pt
		0-10	Pahoehoe lava.	
Kukaiau: KuC, KuD, KuE, KwD	[5] 4-6	0-50	Silty clay loam	OH-MH
		50	Basalt.	
Lalaau: rLLD	0-1	3-0	Muck (extremely stony)	Pt
		0-10	Aa lava.	

See footnotes at end of table.

properties of the soils—Continued

Permeability	Available water capacity [1]	Reaction	Shrink-swell potential	Corrosivity	
				Uncoated steel	Concrete
Inches per hour	*Inches per inch of soil*	*pH*			
6.3–20		4.5–6.0	High	Moderate	Moderate.
6.3–20		7.4–7.8	Low	Low	Low.
6.3–20		7.4–7.8	Low	Low	Low.
6.3–20		8.5–9.4	Low	Low	Low.
2.0–6.3		5.6–7.3	Low	Moderate	Low.
2.0–6.3		6.6–7.3	Low	Low	Low.
2.0–6.3		6.6–7.3	Low	Low	Low.
2.0–6.3		6.1–7.8	Low	Low	Low.
0.63–2.0		6.6–7.8	Low	Low	Low.
6.3–20		5.1–6.0	High [2]	Moderate	Moderate.
6.3–20		5.1–5.5	High [2]	Moderate	Moderate.
6.3–20		5.1–5.5	High [2]	Moderate	Moderate.
6.3–20		7.4–8.4	Low	Low	Low.
6.3–20		7.9–8.4	Low	Moderate	Low.
6.3–20		8.5–>9.1	Low	Moderate	Low.
6.3–20		8.5–>9.1	Low	Moderate	Low.
2.0–6.3		4.5–5.5	High [2]	High	High.
6.3–20		5.1–5.5	High [2]	Moderate	Moderate.
2.0–6.3	0.13–0.15	6.6–7.3	Low	Low	Low.
2.0–6.3	0.13–0.15	7.4–7.8	Low	Low	Low.
2.0–6.3	0.13–0.15	7.4–7.8	Low	Low	Low.
6.3–20		6.6–8.4	Low	Low	Low.
6.3–20		5.1–5.5	High [2]	Moderate	Moderate.
6.3–20		7.4–7.8	Low	Low	Low.
2.0–6.3	0.13–0.15	6.1–7.3	Moderate	Low	Low.
6.3–20		6.1–6.5	High [2]	Low	Low.
2.0–6.3		4.5–6.5	High [2]	Low	Low.
6.3–20		4.5–5.0	High [2]	High	High.

TABLE 2.—*Estimated engineering*

Soil series and map symbols	Depth to bedrock	Depth from surface	Classification	
			Dominant USDA texture	Unified
	Feet	*Inches*		
Laumaia: LAD, LUC	3-6	0-36	Silt loam (LUC: extremely stony)	MH-OH
		36-55	Fine sand	SM
Lava flows, Aa: rLV	0			
Lava flows, pahoehoe: rLW	0			
Mahukona: MHC, MKC	3-6	0-36	Silty clay loam (MKC: very stony)	ML-MH
		36	Saprolite.	
Maile: MaA, MLD	5-7	0-2	Silt loam	OH
		2-60	Silty clay loam	MH-OH
Malama: rMAD	0-1	3-0	Muck (extremely stony)	Pt
		0-10	Fragmental Aa lava.	
Manahaa: MMD, MND	1½-3½	0-25	Silt loam (MND: extremely stony)	MH-OH
		25	Pahoehoe lava.	
Manu: rMUB	1½-3½	0-3	Silt loam	OH
		3-22	Stratified sandy loam and loamy sand	SM
		22-36	Pumice	
		36	Pahoehoe lava.	
Mawae: rMWD	0-1	5-0	Muck (extremely stony)	Pt
		0-10	Fragmental Aa lava.	
Mixed alluvial land: MT. Properties are variable.				
Moaula: MoC, MoD, MoE	5-8	0-74	Silty clay loam	OH-MH
Naalehu: NaC, NaD, NaE, NhD	3½-6	0-65	Silty clay loam and silt loam (NhD: very rocky).	MH-OH
Niulii: NIC, NID, NIE	1½-3½	0-30	Silty clay loam	OH-MH
		30	Pahoehoe lava.	
Ohia: OHC, OSD	[6] 5-8	0-62	Silty clay loam (OSD: extremely stony)	OH
Olaa: OaC, OID	1½-2½	0-25	Silty clay loam (OID: extremely stony)	OH
		25	Fragmental Aa lava.	
Ookala: OoC, OoD, OoE	3½-6	0-55	Silty clay loam	OH-MH
Opihikao: rOPE	0-1	3-0	Muck (extremely rocky)	Pt
		0-10	Pahoehoe lava.	
Paauhau: PaC, PaD, PaE	3-6	0-44	Silty clay loam	OH-MH
		44-60	Silty clay loam (extremely stony)	OH-MH
Pakini: PKB	3½-6	0-60	Very fine sandy loam and loam	ML
Palapalai: PLC, PMC	4-6	0-60	Silt loam	MH-OH
Panaewa: PeC	1-1½	0-16	Silty clay loam	OH
		16	Pahoehoe lava.	
Papai: rPAE	0-1	8-0	Muck (extremely stony)	Pt
		0-10	Aa lava.	
Piihonua: PND, POD	3½-6	0-50	Silty clay loam (POD: extremely stony)	OH
Puaulu: PPC	6-8	0-7	Silt loam	OH
		7-22	Sand, cinders, and ash	OH
		22-72	Clay loam to silt loam	OH

See footnotes at end of table.

properties of the soils—Continued

Permeability	Available water capacity [1]	Reaction	Shrink-swell potential	Corrosivity	
				Uncoated steel	Concrete
Inches per hour	*Inches per inch of soil*	*pH*			
2.0–6.3		5.1–6.0	Low	Moderate	Moderate.
2.0–6.3		5.5–6.0	Low	Moderate	Moderate.
0.63–2.0	0.11–0.13	5.6–7.3	Low	Low	Low.
2.0–6.3		5.6–6.0	Moderate [2]	Low	Low.
2.0–6.3		5.6–7.3	Moderate [2]	Low	Low.
6.3–20		5.1–5.5	High [2]	Moderate	Moderate.
2.0–6.3		6.1–6.5	Moderate [2]	High	Low.
2.0–6.3		5.6–6.0	Moderate	Moderate	Moderate.
6.3–20		5.6–6.5	Low	Moderate	Moderate.
>20		6.6–7.3	Low	Low	Low.
6.3–20		5.6–6.0	High [2]	Moderate	Moderate.
2.0–6.3		4.5–7.3	Moderate [2]	Low	Low.
2.0–6.3		6.1–7.3	Moderate [2]	Low	Low.
2.0–6.3		4.5–6.0	Moderate [2]	Moderate	Moderate.
6.3–20		<4.5	High [2]	Moderate	Moderate.
6.3–20		5.6–6.5	High [2]	Low	Low.
2.0–6.3		4.5–6.5	Moderate [2]	Low to moderate	Low to moderate.
6.3–20		5.1–5.5	High [2]	Moderate	Moderate.
2.0–6.3	0.14–0.16	5.1–6.5	Moderate [2]	Moderate	Moderate.
2.0–6.3	0.04–0.06	5.6–6.5	Low	Low	Low.
6.3–20		6.6–7.7	Low	Low	Low.
2.0–6.3		6.1–7.3	Moderate [2]	Low	Low.
6.3–20		5.1–6.0	High [2]	Moderate	Moderate.
6.3–20		6.1–6.5	High [2]	Low	Low.
6.3–20		<4.5–5.5	High [2]	High	High.
6.3–20		4.5–5.0	High [2]	High	High.
6.3–20		6.1–7.3	Low	Low	Low.
6.3–20		5.6–6.5	Moderate	Moderate	Moderate.

TABLE 2.—*Estimated engineering*

Soil series and map symbols	Depth to bedrock	Depth from surface	Classification: Dominant USDA texture	Classification: Unified
	Feet	*Inches*		
Puhimau: rPHB	1–1½	0–13	Fine sandy loam	SM
		13	Pahoehoe lava.	
Puna: rPXE	0–1	5–0	Muck (extremely stony)	Pt
		0–10	Aa lava.	
Punaluu: rPYD	0–1	4–0	Peat (extremely rocky)	Pt
		0–10	Pahoehoe lava.	
Punohu: PRD	3–6	0–67	Silt loam and silty clay loam	MH–OH
Puukala: PSC, PTC	1–1½	0–18	Silt loam (PSC: extremely stony; PTC: very rocky).	OL–ML
		18	Pahoehoe lava.	
Puu Oo: PUC	3½–6	0–50	Silt loam, silty clay loam, and sandy clay loam.	MH–CH
Puu Pa: PVD, PVF3, PWD	1½–5	0–40	Very fine sandy loam and silt loam (PVD and PVF3; extremely stony).	ML
		40	Aa lava.	
Rock land: rRO. Properties are variable.				
Rough broken land: RB. Properties are variable.				
Tropaquepts: Tr. Properties are variable.				
Tropofolists	0–1	4–0	Muck	Pt
		0–10	Aa or pahoehoe lava.	
Umikoa: UMD, USD	3½–6	0–60	Silt loam and silty clay loam (USD; extremely stony).	MH–CH
Very stony land: rVS. Properties are variable.				
Waiaha: WAC, WAD, WHC, WKD	1–1½	0–18	Silt loam (WHC; extremely stony; WKD; very rocky).	ML
		18	Pahoehoe lava.	
Waikaloa: WLC	1½–6	0–25	Very fine sandy loam	ML
		25–50	Silty clay loam	MH
		50–65	Sandy loam	SM
Waimea: WMC, WSD	2½–5	0–42	Very fine sandy loam, loam, and silt loam (WSD: extremely stony).	ML
		42	Basalt.	

[1] Estimates are given only for soils now irrigated.
[2] In their natural state, these soils are always moist. When dried they have high shrinkage but low swelling potential.
[3] Seasonal high water table is at a depth of 1 to 2 feet.

properties of the soils—Continued

Permeability	Available water capacity [1]	Reaction	Shrink-swell potential	Corrosivity	
				Uncoated steel	Concrete
Inches per hour	*Inches per inch of soil*	*pH*			
6.3–20		5.6–6.5	Low	Low	Low.
6.3–20		6.1–6.5	High [2]	Low	Low.
6.3–20		5.6–6.0	High [2]	Low	Low.
2.0–6.3		5.6–6.0	Moderate [2]	Moderate	Moderate.
6.3–20		5.1–6.0	High [2]	Moderate	Moderate.
2.0–6.3		<4.5–5.5	High [2]	High	High.
2.0–6.3		5.6–7.3	Low	Low	Low.
6.3–20		4.5–5.0	High [2]	High	High.
2.0–6.3		5.6–6.5	Moderate	Moderate	Low.
2.0–6.3		6.1–7.8	Low	Low	Low.
2.0–6.3		6.6–7.3	Low	Low	Low.
0.63–2.0		6.6–7.8	Low	Low	Low.
2.0–6.3		7.4–7.8	Low	Low	Low.
2.0–6.3	0.14–0.16	6.6–7.8	Low	Low	Low.

[4] Depth to bedrock variable.
[5] Depth to bedrock 1½ to 2½ feet in KwD.
[6] Depth to bedrock 1½ to 3 feet in OSD.

TABLE 3.—*Engineering*

[Blank space indicates practice is not applicable or not needed. An asterisk in the first column indicates that at least one mapping unit in this reason it is necessary to follow carefully the instructions for referring

Soil series and map symbols	Suitability as source of—		Soil features affecting—	
	Topsoil	Road fill	Highway location	Farm ponds: Reservoir area
Ainakea: AaC, AaD, AaE.	Fair: bedrock at depth of 2 to 3½ feet.	Fair: moderate compressibility; low to moderate density if compacted; high organic-matter content.	Bedrock at depth of 2 to 3½ feet; slopes up to 35 percent.	High seepage loss; slopes up to 35 percent.
Akaka: AkC, AkD, rAK.	Poor to fair: continuous wetness; irreversible dehydration into gravel-size aggregates.	Poor: high compressibility; low density if compacted; poor workability; continuous wetness; high organic-matter content.	Low bearing capacity; continuous wetness.	High seepage loss
Alapai: AlC, AlD, AlE, ApD.	Poor to fair: wetness; irreversible dehydration into gravel-size aggregates; stoniness in places.	Poor: high compressibility; low density if compacted; poor workability; continuous wetness; high organic-matter content.	Low bearing capacity; continuous wetness; slopes up to 35 percent; stoniness in places.	High seepage loss; slopes slopes up to 35 percent; stoniness in places.
*Amalu: rAM, rAR. For Rough broken land part of rAR, see Rough broken land.	Poor: low fertility; mucky surface layer; bedrock at depth of 1 to 2 feet; continuous wetness.	Poor: high compressibility; low density if compacted; poor workability; continuous wetness; bedrock at depth of 1 to 2 feet; high organic-matter content.	Low bearing capacity; continuous wetness; bedrock at depth of 1 to 2 feet.	High seepage loss
Apakuie: AFD, ASD	Fair: high erodibility; instability on steep slopes; stoniness in places.	Fair: moderate density if compacted; high erodibility; unstable slopes.	Unstable slopes; high erodibility; stoniness in places.	High seepage loss; stoniness in places.
Beaches: BH	Poor: low fertility; high erodibility; low available water capacity.	Good if confined or soil binder added: erodibility.	Subject to tidal action	High seepage loss; subject to tidal action.
Cinder land: rCL		Fair to poor: unstable slopes; low density if compacted.	Erodibility; unstable slopes.	Very rapid permeability
Fill land: FL	Fair to good: variable depth.	Variable	Variable	Variable
Hanipoe: HCD	Poor: stoniness; Aa lava at depth of 1½ to 2½ feet.	Fair: stoniness; moderate compressibility; unstable slopes; low density if compacted.	Stoniness; Aa lava at depth of 1½ to 2½ feet; unstable slopes.	Aa lava at depth of 1½ to 2½ feet; high seepage loss.
Hanipoe: HDD, HFD	Good	Fair: moderate compressibility; unstable slopes; low density if compacted.	Moderate bearing capacity; unstable slopes.	High seepage loss

interpretations

series is made up of two or more kinds of soil. The soils in such mapping units may have different properties and limitations, and for this to other series that appear in the first column of this table]

Soil features affecting—Continued				Degree and kind of limitations for septic tank filter fields
Farm ponds—continued: Embankment	Terraces and diversions	Grassed waterways	Foundations for low buildings	
Low to moderate density if compacted; moderate permeability if compacted; high organic-matter content; slopes up to 35 percent.	Bedrock at depth of 2 to 3½ feet; slopes up to 35 percent.	Bedrock at depth of 2 to 3½ feet; slopes up to 35 percent.	Moderate bearing capacity; bedrock at depth of 2 to 3½ feet; moderate compressibility; high organic-matter content.	Severe: bedrock at depth of 2 to 3½ feet; slopes up to 35 percent.
Poor workability; low density if compacted; high shrinkage; high organic-matter content; high compressibility.	Continuous wetness; poor workability.	Continuous wetness; poor workability.	Low bearing capacity; high compressibility; low shear strength; subject to sliding; high shrinkage; high organic-matter content.	Slight to severe, depending on slope.
Poor workability; low density if compacted; high organic-matter content; high shrinkage; slopes up to 35 percent; stoniness in places.	Continuous wetness; poor workability; slopes up to 35 percent; stoniness in places.	Continuous wetness; poor workability; slopes up to 35 percent; stoniness in places.	Low bearing capacity; high compressibility; low shear strength; subject to sliding; high shrinkage; high organic-matter content.	Slight to severe, depending on slope.
High organic-matter content; poor workability; high compressibility; low density if compacted.	Shallowness to ironstone sheet; poor workability; continuous wetness.	Poor drainage; shallowness to bedrock.	Bedrock at depth of 1 to 2 feet; low bearing capacity; high compressibility; subject to sliding; high organic-matter content.	Severe: poor drainage; bedrock at depth of 1 to 2 feet.
Moderate density if compacted; unstable slopes; high erodibility; subject to piping; stoniness in places.	High erodibility; plants difficult to establish; unstable slopes; stoniness in places.	High erodibility; plants difficult to establish; stoniness in places.	Moderate compressibility; stoniness in places.	Slight to severe, depending on slopes.
----------	----------	----------	Subject to tidal action	Severe: subject to tidal action.
----------	----------	----------	Moderate compressibility.	Slight to severe, depending on slope: very rapid premeability; may contaminate ground water in places.
Variable	Variable	Variable	Variable	Variable.
Stoniness; low density if compacted; high erodibility; unstable slopes; subject to piping.	Stoniness; high erodibility; unstable slopes; Aa lava at depth of 1½ to 2½ feet.	Stoniness; high erodibility; Aa lava at depth of 1½ to 2½ feet.	Moderate bearing capacity; moderate compressibility.	Severe: slopes 12 to 20 percent; Aa lava at depth of 1½ to 2½ feet.
Low density if compacted; high erodibility; unstable slopes; subject to piping.	High erodibility; unstable slopes.	High erodibility	Moderate bearing capacity; moderate compressibility.	Moderate to severe: slopes 6 to 20 percent.

TABLE 3.—*Engineering*

Soil series and map symbols	Suitability as source of— Topsoil	Road fill	Soil features affecting— Highway location	Farm ponds: Reservoir area
Hawi: HaA, HaC	Good	Fair to good: moderate shrink-swell potential.	Moderate shrink-swell potential.	Moderate permeability
Hawi: HeC	Fair: stoniness	Fair to good: moderate shrink-swell potential; stoniness.	Stoniness; moderate shrink-swell potential.	Moderate permeability
Heake: HHC, HKC	Poor: rockiness; bedrock at depth of 1 to 2 feet.	Poor: rockiness; bedrock at depth of 1 to 2 feet.	Rockiness; bedrock at depth of 1 to 2 feet.	Bedrock at depth of 1 to 2 feet; high seepage loss.
Hilea: HIC	Fair to poor: bedrock at depth of less than 2 feet; continuous wetness; irreversible dehydration into gravel-size aggregates.	Poor: bedrock at depth of less than 2 feet; high compressibility; low density if compacted; poor workability; continuous wetness; high organic-matter content.	Bedrock at depth of less than 2 feet; low bearing capacity; continuous wetness.	Bedrock at depth of less than 2 feet; high seepage loss.
Hilo: HoC, HoD, HoE	Fair to poor: continuous wetness; irreversible dehydration into gravel-size aggregates.	Poor: high compressibility; low density if compacted; poor workability; continuous wetness; high organic-matter content.	Low bearing capacity; continuous wetness; slopes up to 35 percent.	High seepage loss; slopes up to 35 percent.
Honaunau: HND, HRD	Fair to poor: bedrock at depth of 1½ to 2½ feet; continuous wetness; irreversible dehydration into gravel-size aggregates; extreme rockiness in places.	Poor: bedrock at depth of 1½ to 2½ feet; high compressibility; low density if compacted; poor workability; continuous wetness.	Bedrock at depth of 1½ to 2½ feet; low bearing capacity; continuous wetness; extreme rockiness in places.	Bedrock at depth of 1½ to 2½ feet; high seepage loss.
Honokaa: HsC, HsD, HsE, HTD, HTE.	Poor to fair: continuous wetness; irreversible dehydration into gravel-size aggregates.	Poor: high compressibility; low density if compacted; poor workability; continuous wetness; high organic-matter content.	Low bearing capacity; high compressibility; continuous wetness; poor workability; slopes up to 35 percent.	High seepage loss; slopes up to 35 percent.
Honuaulu: HUD, HVD.	Fair: stoniness; fragmental Aa lava at depth of 1½ to 3½ feet.	Poor: fragmental Aa lava at depth of 1½ to 3½ feet; high compressibility; low density if compacted; high organic-matter content.	Low bearing capacity; high compressibility; fragmental Aa lava at depth of 1½ to 3½ feet; stoniness.	High seepage loss
Huikau: rHID, rHID2	Fair: high erodibility; instability on steep slopes; sand and cinders at depth of 2 feet.	Fair: moderate density if compacted; high erodibility; unstable slopes; sand and cinders at depth of 2 feet.	Instability on steep slopes; high erodibility; sand and cinders at depth of 2 feet.	High seepage loss; unstable slopes; sand and cinders at depth of 2 feet.

interpretations—Continued

Soil features affecting—Continued					Degree and kind of limitations for septic tank filter fields
Farm ponds—continued	Terraces and diversions	Grassed waterways	Foundations for low buildings		
Embankment					
Moderate shrink-swell potential.	Moderate shrink-swell potential.	Plants difficult to establish.	Moderate shrink-swell potential.		Slight to moderate: moderate permeability; slopes 0 to 12 percent.
Stoniness; moderate shrink-swell potential.	Stoniness; moderate shrink-swell potential.	Stoniness; plants difficult to establish.	Moderate shrink-swell potential.		Moderate: moderate permeability; slopes 6 to 12 percent.
Rockiness; low density if compacted; unstable slopes; high erodibility; limited volume of material.	Rockiness; unstable slopes; high erodibility; bedrock at depth of 1 to 2 feet.	Rockiness; high erodibility; bedrock at depth of 1 to 2 feet.	Bedrock at depth of 1 to 2 feet.		Severe: bedrock at depth of 1 to 2 feet.
Limited volume of material; high compressibility; low density if compacted; high organic-matter content.	Bedrock at depth of less than 2 feet; continuous wetness; poor workability.	Bedrock at depth of less than 2 feet; continuous wetness; poor workability.	Bedrock at depth of less than 2 feet; low bearing capacity; low shear strength; high compressibility; high organic-matter content.		Severe: bedrock at depth of less than 2 feet.
Slopes up to 35 percent; low density if compacted; high organic-matter content; high compressibility.	Continuous wetness; poor workability; slopes up to 35 percent.	Continuous wetness; poor workability; slopes up to 35 percent.	Low bearing capacity; high compressibility; low shear strength; subject to sliding; high shrinkage; high organic-matter content.		Slight to severe, depending on slope.
Limited volume of material; high compressibility; low density if compacted; high organic-matter content; extreme rockiness in places.	Bedrock at depth of 1½ to 2½ feet; continuous wetness; poor workability; extreme rockiness in places.	Bedrock at depth of 1½ to 2½ feet; continuous wetness; poor workability; extreme rockiness in places.	Bedrock at depth of 1½ to 2½ feet; low bearing capacity; high compressibility; low shear strength; high shrinkage; high organic-matter content.		Severe: bedrock at depth of 1½ to 2½ feet.
Poor workability; low density if compacted; high organic-matter content; high compressibility; slopes up to 35 percent.	Continuous wetness; poor workability; slopes up to 35 percent.	Continuous wetness; poor workability; slopes up to 35 percent.	Low bearing capacity; high compressibility; low shear strength; subject to sliding; high shrinkage; high organic-matter content.		Slight to severe, depending on slope.
Stoniness; low density if compacted; high compressibility; high organic-matter content.	Fragmental Aa lava at depth of 1½ to 3½ feet; stoniness.	Fragmental Aa lava at depth of 1½ to 3½ feet; stoniness.	Low bearing capacity; high compressibility; fragmental Aa lava at depth of 1½ to 3½ feet; high organic-matter content.		Severe; slopes up to 20 percent; fragmental Aa lava at depth of 1½ to 3½ feet.
Moderate density if compacted; unstable slopes; high erodibility; subject to piping.	High erodibility; unstable slopes; plants difficult to establish; sand and cinders at depth of 2 feet.	High erodibility; plants difficult to establish; sand and cinders at depth of 2 feet.	Poor stability unless confined.		Severe: slopes 12 to 20 percent.

TABLE 3.—*Engineering*

Soil series and map symbols	Suitability as source of—		Soil features affecting—	
	Topsoil	Road fill	Highway location	Farm ponds: Reservoir area
Huikau: rHLD	Fair: stoniness; fragmental Aa lava at depth of 2½ to 3½ feet; high erodibility; instability on steep slopes.	Fair: moderate density if compacted; high erodibility; unstable slopes.	Instability on steep slopes; high erodibility; fragmental Aa lava at depth of 2½ to 3½ feet; stoniness.	Stoniness; high seepage loss; unstable slopes.
*Hydrandepts: rHP. For Tropofolist part, see Tropofolists.	Poor to fair: continuous wetness; irreversible dehydration into gravel-size aggregates.	Poor: high compressibility; low density if compacted; poor workability; continuous wetness.	Low bearing capacity; continuous wetness.	High seepage loss
Kaalualu: KBC	Poor: stoniness; fragmental Aa lava at depth of 2½ to 4 feet.	Fair: high erodibility; instability on steep slopes; stoniness.	Instability on steep slopes; high erodibility; stoniness; fragmental Aa lava at depth of 2½ to 4 feet.	High seepage loss; fragmental Aa lava at depth of 2½ to 4 feet.
Kahaluu: rKAD	Poor: pahoehoe lava at depth of less than 10 inches.	Poor: pahoehoe lava at depth of less than 10 inches.	Pahoehoe lava at depth of less than 10 inches.	Pahoehoe lava at depth of less than 10 inches.
Kahua: KCD	Poor: continuous wetness; irreversible dehydration into gravel-size aggregates.	Poor: high compressibility; low density if compacted; poor workability; continuous wetness.	Low bearing capacity; high compressibility; continuous wetness; poor workability.	High seepage loss
Kaimu: rKED	Poor: fragmental Aa lava at depth of less than 10 inches.	Poor: peat surface layer	Fragmental Aa lava at depth of less than 10 inches.	Fragmental Aa lava at depth of less than 10 inches.
Kainaliu: KDD, KEC	Fair: stoniness; fragmental Aa lava at depth of 1½ to 3½ feet.	Fair: moderate compressibility; fragmental Aa lava at depth of 1½ to 3½ feet.	Moderate bearing capacity; moderate compressibility; erodibility on steep slopes; stoniness.	High seepage loss
Kaiwiki: KaC, KaD, KaE.	Poor to fair: continuous wetness; irreversible dehydration into gravel-size aggregates.	Poor: high compressibility; low density if compacted; poor workability; continuous wetness; low shear strength; high organic-matter content.	Low bearing capacity; high compressibility; continuous wetness; poor workability; slopes up to 35 percent.	High seepage loss; slopes up to 35 percent.
Kamakoa: KGC	Fair: high erodibility; sandiness.	Fair: unstable slopes; high erodibility.	Moderate bearing capacity; high erodibility.	High seepage loss
Kamaoa: KIC, KKC	Good to fair: stoniness in places.	Fair: moderate compressibility; high erodibility; stoniness in places.	Moderate bearing capacity; moderate compressibility; high erodibility; stoniness in places.	High seepage loss; stoniness in places.
Kamaoa: KJC	Fair: bedrock at depth of 1½ to 2½ feet.	Fair: moderate compressibility; high erodibility; bedrock at depth of 1½ to 2½ feet.	Moderate bearing capacity; moderate compressibility; high erodibility; bedrock at depth of 1½ to 2½ feet.	High seepage loss; bedrock at depth of 1½ to 2½ feet.

interpretations—Continued

Soil features affecting—Continued				Degree and kind of limitations for septic tank filter fields
Farm ponds—continued: Embankment	Terraces and diversions	Grassed waterways	Foundations for low buildings	
Stoniness; moderate density if compacted; unstable slopes; high erodibility; subject to piping.	Stoniness; high erodibility; plants difficult to establish.	Stoniness; high erodibility; plants difficult to establish.	Poor stability unless confined.	Severe: slopes 12 to 20 percent.
Poor workability; low density if compacted; high shrinkage; high organic-matter content; high compressibility.	Continuous wetness; poor workability.	Continuous wetness; poor workability.	Low bearing capacity; high compressibility; low shear strength; subject to sliding; high shrinkage.	Slight to severe, depending on slope.
Limited volume of material; stoniness; unstable slopes; high erodibility.	Stoniness; fragmental Aa lava at depth of 2½ to 4 feet; unstable slopes; high erodibility.	Stoniness; fragmental Aa lava at depth of 2½ to 4 feet; high erodbility; plants difficult to establish.	Fragmental Aa lava at depth of 2½ to 4 feet.	Slight.
Pahoehoe lava at depth of less than 10 inches.	----------	----------	Pahoehoe lava at depth of less than 10 inches.	Severe: pahoehoe lava at depth of less than 10 inches.
Low density if compacted; poor workability; high compressibility; high shrinkage.	Poor workability; continuous wetness.	Poor workability; continuous wetness.	Low bearing capacity; high compressibility; low shear strength; subject to sliding.	Severe: ironstone seam at depth of 8 to 15 inches; slopes up to 20 percent; continuous wetness.
Fragmental Aa lava at depth of less than 10 inches.	----------	----------	Fragmental Aa lava at depth of less than 10 inches.	Severe: fragmental Aa lava at depth of less than 10 inches.
Stoniness; moderate compressibility; unstable slopes; subject to piping.	Stoniness; unstable slopes; fragmental Aa lava at depth of 1½ to 3½ feet.	Stoniness; fragmental Aa lava at depth of 1½ to 3½ feet.	Fragmental Aa lava at depth of 1½ to 3½ feet; moderate compressibility.	Severe: slopes greater than 10 percent; fragmental Aa lava at depth of 1½ to 3½ feet.
Poor workability; low density if compacted; high organic-matter content; high compressibility; slopes up to 35 percent.	Continuous wetness; poor workability; slopes up to 35 percent.	Continuous wetness; poor workability; slopes up to 35 percent.	Low bearing capacity; high compressibility; low shear strength; subject to sliding; high shrinkage; high organic-matter content.	Slight to severe, depending on slope.
High erodibility; unstable slopes; subject to piping.	High erodibility; unstable slopes; plants difficult to establish.	High erodibility; droughtiness; plants difficult to establish.	Moderate compressibility.	Slight to moderate, depending on slope.
High erodibility; unstable slopes; subject to piping; stoniness in places.	High erodibility; unstable slopes; stoniness in places.	High erodibility; stoniness in places.	Moderate bearing capacity; moderate compressibility.	Moderate to severe, depending on slope.
High erodibility; unstable slopes; subject to piping.	Bedrock at depth of 1½ to 2½ feet; high erodibility; unstable slopes.	Bedrock at depth of 1½ to 2½ feet; high erodibility.	Bedrock at depth of 1½ to 2½ feet; moderate bearing capacity.	Severe: bedrock at depth of 1½ to 2½ feet.

TABLE 3.—*Engineering*

Soil series and map symbols	Suitability as source of—		Soil features affecting—	
	Topsoil	Road fill	Highway location	Farm ponds: Reservoir area
Kapapala: KLC, KLD	Good	Fair: moderate compressibility; unstable slopes; low density if compacted.	Moderate bearing capacity; instability on moderately steep slopes.	High seepage loss
Kapapala: KMD	Poor: rockiness; bedrock at depth of 1½ to 2½ feet.	Fair: moderate compressibility; unstable slopes; low density if compacted; rockiness; bedrock at depth of 1½ to 2½ feet.	Moderate bearing capacity; instability on moderately steep slopes; rockiness; bedrock at depth of 1½ to 2½ feet.	Bedrock at depth of 1½ to 2½ feet; high seepage loss.
Kawaihae: KNC, KOC	Poor: rockiness and stoniness; bedrock at depth of 1½ to 3½ feet; high erodibility; instability on steep slopes.	Fair: moderate density if compacted; high erodibility; unstable slopes.	Unstable slopes; high erodibility; stoniness and rockiness; bedrock at depth of 1½ to 3½ feet.	High seepage loss
Kealakekua: KPD, KRD, KSD.	Poor to fair: continuous wetness; irreversible dehydration into gravel-size aggregates; stoniness in places.	Poor: high compressibility; low density if compacted; poor workability; continuous wetness; high organic-matter content.	Low bearing capacity; high compressibility; continuous wetness; poor workability.	High seepage loss; bedrock at depth of 1½ to 4 feet; stoniness in places.
Keaukaha: rKFD	Poor: pahoehoe lava at depth of less than 10 inches.	Poor: pahoehoe lava at depth of less than 10 inches.	Pahoehoe lava at depth of less than 10 inches.	Pahoehoe lava at depth of less than 10 inches.
Keei: rKGD	Poor: pahoehoe lava at depth of less than 10 inches.	Poor: pahoehoe lava at depth of less than 10 inches.	Pahoehoe lava at depth of less than 10 inches.	Pahoehoe lava at depth of less than 10 inches.
Keekee: KTB	Good in upper 15 inches, fair below: high erodibility; unstable slopes.	Fair: moderate density if compacted; high erodibility; unstable slopes.	Unstable slopes	High seepage loss
Kehena: KVC	Poor: bedrock at depth of 1½ to 4 feet; continuous wetness; irreversible dehydration into gravel-size aggregates.	Poor: high compressibility; low density if compacted; continuous wetness; poor workability; high organic-matter content.	Low bearing capacity; high compressibility; continuous wetness; poor workability.	High seepage loss
Kekake: rKHD	Poor: pahoehoe lava at depth of less than 10 inches.	Poor: pahoehoe lava at depth of less than 10 inches.	Pahoehoe lava at depth of less than 10 inches.	Pahoehoe lava at depth of less than 10 inches.
Kikoni: KfA, KXC, KYC.	Good (KfA and KXC), fair (KYC): stoniness in places.	Fair: moderate compressibility; high erodibility; stoniness in places.	Moderate bearing capacity; moderate compressibility; high erodibility; stoniness in places.	High seepage loss; stoniness in places.
Kilauea: rKUC	Poor: gravelly sand texture.	Good	Gravelly sand; unstable slopes.	High seepage loss
Kiloa: rKXD	Poor: fragmental Aa lava at depth of less than 10 inches.	Poor: mucky surface layer.	Fragmental Aa lava at depth of less than 10 inches.	Fragmental Aa lava at depth of less than 10 inches.

interpretations—Continued

Soil features affecting—Continued				Degree and kind of limitations for septic tank filter fields
Farm ponds—continued: Embankment	Terraces and diversions	Grassed waterways	Foundations for low buildings	
Low density if compacted; high erodibility; unstable slopes; subject to piping.	High erodibility; unstable slopes.	High erodibility	Moderate bearing capacity; moderate compressibility.	Slight to severe, depending on slope.
Rockiness; limited volume of material; moderate density if compacted; high erodibility; subject to piping.	Rockiness; high erodibility; unstable slopes.	Rockiness; high erodibility.	Bedrock at depth of 1½ to 2½ feet; moderate bearing capacity; moderate compressibility; subject to piping.	Severe: bedrock at depth of 1½ to 2½ feet.
Rockiness and stoniness; moderate density if compacted; unstable slopes; high erodibility; subject to piping.	Rockiness and stoniness; high erodibility; unstable slopes; bedrock at depth of 1½ to 3½ feet.	Rockiness and stoniness; high erodibility; bedrock at depth of 1½ to 3½ feet; plants difficult to establish.	Bedrock at depth of 1½ to 3½ feet; stoniness and rockiness.	Severe: bedrock at depth of 1½ to 3½ feet.
Poor workability; low density if compacted; high organic-matter content; high compressibility.	Bedrock at depth of 1½ to 4 feet; poor workability; continuous wetness; stoniness in places.	Bedrock at depth of 1½ to 4 feet; poor workability; continuous wetness; stoniness in places.	Bedrock at depth of 1½ to 4 feet; low bearing capacity; high compressibility; low shear strength; subject to sliding; high organic-matter content.	Severe: bedrock at depth of 1½ to 4 feet; slopes up to 20 percent.
Pahoehoe lava at depth of less than 10 inches.			Pahoehoe lava at depth of less than 10 inches.	Severe: pahoehoe lava at depth of less than 10 inches.
Pahoehoe lava at depth of less than 10 inches.			Pahoehoe lava at depth of less than 10 inches.	Severe: pahoehoe lava at depth of less than 10 inches.
Moderate density if compacted; unstable slopes; high erodibility; subject to piping.	High erodibility; unstable slopes; plants difficult to establish.	High erodibility; plants difficult to establish.	Moderate compressibility; moderate shear strength; moderate bearing capacity.	Slight to moderate, depending on slope.
Poor workability; low density if compacted; high organic-matter content; high shrinkage.	Somewhat poor drainage; poor workability.	Somewhat poor drainage; poor workability.	Bedrock at depth of 1½ to 4 feet; low bearing capacity; high compressibility; low shear strength; high organic-matter content.	Severe: bedrock at depth of 1½ to 4 feet.
Pahoehoe lava at depth of less than 10 inches.			Pahoehoe lava at depth of less than 10 inches.	Severe: pahoehoe lava at depth of less than 10 inches.
High erodibility; subject to piping; unstable slopes; stoniness in places.	High erodibility; unstable slopes; stoniness in places.	High erodibility; stoniness in places.	Moderate bearing capacity; moderate compressibility.	Slight to moderate, depending on slope.
Moderate slope stability; high erodibility; vegetation difficult to establish.	High erodibility; unstable slopes; plants difficult to establish.	High erodibility; plants difficult to establish.	All features favorable	Slight to moderate, depending on slope.
Fragmental Aa lava at depth of less than 10 inches.			Fragmental Aa lava at depth of less than 10 inches.	Severe: fragmental Aa lava at depth of less than 10 inches.

TABLE 3.—*Engineering*

Soil series and map symbols	Suitability as source of—		Soil features affecting—	
	Topsoil	Road fill	Highway location	Farm ponds: Reservoir area
Kilohana: KZD	Good in upper 11 inches, fair below: unstable slopes; high erodibility.	Fair: moderate density if compacted; high erodibility; unstable slopes.	Unstable slopes; high erodibility.	High seepage loss; sand and cinders below depth of 3 feet.
Kohala: KhA, KhC, KhD, KhE.	Good	Good	Slopes up to 35 percent	Moderately rapid permeability; slopes up to 35 percent.
Kona: rKYD	Poor: pahoehoe lava at depth of less than 10 inches.	Poor: pahoehoe lava at depth of less than 10 inches.	Pahoehoe lava at depth of less than 10 inches.	Pahoehoe lava at depth of less than 10 inches.
Kukaiau: KuC, KuD, KuE.	Good	Poor: high compressibility; low density if compacted; high organic-matter content.	Low bearing capacity; high compressibility; slopes up to 35 percent.	High seepage loss; slopes up to 35 percent.
Kukaiau: KwD	Fair: bedrock at depth of 1½ to 2½ feet.	Poor: high compressibility; low density if compacted; bedrock at depth of 1½ to 2½ feet; high organic-matter content.	Low bearing capacity; high compressibility; slopes up to 35 percent; bedrock at depth of 1½ to 2½ feet.	High seepage loss; slopes up to 35 percent; bedrock at depth of 1½ to 2½ feet.
Lalaau: rLLD	Poor: fragmental Aa lava at depth of less than 10 inches.	Poor: mucky surface layer.	Fragmental Aa lava at depth of less than 10 inches.	Fragmental Aa lava at depth of less than 10 inches.
Laumaia: LAD, LUC	Good (LAD), fair (LUC): stoniness in places.	Fair: moderate compressibility; low density if compacted; erodibility; stoniness in places.	Moderate bearing capacity; unstable slopes; stoniness in places.	High seepage loss; stoniness in places.
Lava flows, Aa: rLV		Good in fragmental surface layer.	Aa lava	Aa lava
Lava flows, pahoehoe: rLW.			Pahoehoe lava	Pahoehoe lava
Mahukona: MHC, MKC.	Good (MKC), fair (MHC): stoniness in places.	Moderately stable slopes.	Stoniness in places	Moderate permeabilily; stoniness in places.
Maile: MaA, MLD	Good	Poor: high compressibility; low density if compacted; high organic-matter content.	Low bearing capacity; high compressibility.	High seepage loss
Malama: rMAD	Poor: fragmental Aa lava at depth of less than 10 inches.	Poor: mucky surface layer.	Fragmental Aa lava at depth of less than 10 inches.	Fragmental Aa lava at depth of less than 10 inches.

interpretations—Continued

Soil features affecting—Continued					Degree and kind of limitations for septic tank filter fields
Farm ponds—continued	Terraces and diversions	Grassed waterways	Foundations for low buildings		
Embankment					
Moderate density if compacted; unstable slopes.	High erodibility; unstable slopes; sand and cinders below depth of 3 feet.	High erodibility; sand and cinders below depth of 3 feet; plants difficult to establish.	All features favorable		Severe: slopes 12 to 20 percent.
Slopes up to 35 percent	Slopes up to 35 percent	Slopes up to 35 percent	All features favorable		Slight to severe, depending on slope.
Pahoehoe lava at depth of less than 10 inches.			Pahoehoe lava at depth of less than 10 inches.		Severe: slopes up to 20 percent; pahoehoe lava at depth of less than 10 inches.
Low density if compacted; high compressibility; high organic-matter content; slopes up to 35 percent.	Slopes up to 35 percent	Slopes up to 35 percent	Low bearing capacity; high compressibility; high organic-matter content.		Moderate to severe, depending on slope.
Low density if compacted; high compressibility; high organic-matter content; slopes up to 35 percent.	Bedrock at depth of 1½ to 2½ feet.	Bedrock at depth of 1½ to 2½ feet.	Low bearing capacity; high compressibility; bedrock at depth of 1½ to 2½ feet; high organic-matter content.		Severe: bedrock at depth of 1½ to 2½ feet.
Fragmental Aa lava at depth of less than 10 inches.			Fragmental Aa lava at depth of less than 10 inches.		Severe: fragmental Aa lava at depth of less than 10 inches.
High organic-matter content; moderate density if compacted; unstable slopes; subject to piping; stoniness in places.	Unstable slopes; high erodibility; stoniness in places.	High erodibility; stoniness in places.	Moderate bearing capacity; moderate compressibility.		Moderate to severe, depending on slope.
			Aa lava		Severe: Aa lava.
			Pahoehoe lava		Severe: pahoehoe lava.
Moderately stable slopes; stoniness in places.	Moderately stable slopes; plants difficult to establish; stoniness in places.	Plants difficult to establish; stoniness in places.	Moderate compressibility; moderate shear strength; moderate bearing capacity.		Moderate: slopes up to 12 percent.
Low density if compacted; high organic-matter content.	Poor workability	Poor workability	High compressibility; low bearing capacity; low shear strength; subject to sliding; high organic-matter content.		Moderate to severe, depending on slope.
Fragmental Aa lava at depth of less than 10 inches.			Fragmental Aa lava at depth of less than 10 inches.		Severe: fragmental Aa lava at depth less than 10 inches

TABLE 3.—*Engineering*

Soil series and map symbols	Suitability as source of— Topsoil	Road fill	Soil features affecting— Highway location	Farm ponds: Reservoir area
Manahaa: MMD, MND.	Good (MMD), fair (MND): stoniness in places.	Poor: high compressibility; low density if compacted; bedrock at depth of 1½ to 3½ feet; stoniness in places; high organic-matter content.	Low bearing capacity; high compressibility; stoniness in places; high organic-matter content.	High seepage loss; stoniness in places.
Manu: rMUB	Good	Poor: high compressibility; low density if compacted.	Bedrock at depth of 1½ to 3½ feet; low bearing capacity; high compressibilty.	High seepage loss
Mawae: rMWD	Poor: fragmental Aa lava at depth of less than 10 inches.	Poor: mucky surface layer.	Fragmental Aa lava at depth of less than 10 inches.	Fragmental Aa lava at depth of less than 10 inches.
Mixed alluvial land: MT. Properties are variable.				
Moaula: MoC, MoD, MoE.	Good	Poor: high compressibility; low density if compacted; high organic-matter content.	Low bearing capacity; high compressibility; slopes up to 35 percent.	High seepage loss; slopes up to 35 percent.
Naalehu: NaC, NaD, NaE.	Good	Fair: moderate compressibility; high erodibility on steep slopes.	Moderate bearing capacity; high erodibility on steep slopes; slopes up to 35 percent.	High seepage loss; slopes up to 35 percent.
Naalehu: NhD	Good	Fair: rockiness; bedrock at depth of 1½ to 3 feet; moderate compressibility; high erodibility on steep slopes.	Rockiness; bedrock at depth of 1½ to 3 feet; moderate bearing capacity; moderate compressibility.	Rockiness; high seepage loss.
Niulii: NIC, NID, NIE.	Good	Poor: high compressibility; low density if compacted; high organic-matter content.	Low bearing capacity; high compressibility; slopes up to 35 percent.	High seepage loss; slopes up to 35 percent.
Ohia: OHC, OSD	Poor to fair: continuous wetness; irreversible dehydration into gravel-size aggregates; stoniness in places.	Poor: high compressibility; low density if compacted; poor workability; continuous wetness; stoniness in places; high organic-matter content.	Low bearing capacity; high compressibility; continuous wetness; stoniness in places; high organic-matter content.	High seepage loss
Olaa: OaC, OlD	Poor to fair: stoniness; fragmental Aa lava at depth of 1½ to 2½ feet; irreversible dehydration into gravel-size aggregates.	Poor: stoniness; fragmental Aa lava at depth of 1½ to 2½ feet; high compressibility; low density if compacted; poor workability; high organic-matter content.	Stoniness; fragmental Aa lava at depth of 1½ to 2½ feet; high compressibility; low bearing capacity; continous wetness.	High seepage loss

interpretations—Continued

Soil features affecting—Continued: Farm ponds—continued: Embankment	Terraces and diversions	Grassed waterways	Foundations for low buildings	Degree and kind of limitations for septic tank filter fields
Low density if compacted; high compressibility; high organic-matter content; stoniness in places.	Bedrock at depth of 1½ to 3½ feet; stoniness in places.	Poor workability; bedrock at depth of 1½ to 3½ feet; stoniness in places.	Bedrock at depth of 1½ to 3½ feet; high compressibility; low shear strength; subject to sliding; high organic-matter content.	Severe: bedrock at depth of 1½ to 3½ feet; slopes up to 20 percent.
Low density if compacted; high compressibility; high organic-matter content; subject to piping.	Bedrock at depth of 1½ to 3½ feet.	Bedrock at depth of 1½ to 3½ feet; poor workability.	Bedrock at depth of 1½ to 3½ feet; high compressibility; low bearing capacity.	Severe: bedrock at depth of 1½ to 3½ feet.
Fragmental Aa lava at depth of less than 10 inches.			Fragmental Aa lava at depth of less than 10 inches.	Severe: fragmental Aa lava at depth of less than 10 inches.
Low density if compacted; high compressibility; high organic-matter content.	Slopes up to 35 percent; poor workability.	Slopes up to 35 percent; poor workability.	Low bearing capacity; high compressibility; high organic-matter content.	Slight to severe, depending on slope.
High erodibility; unstable slopes; slopes up to 35 percent.	High erodibility; unstable slopes; slopes up to 35 percent.	High erodibility; slopes up to 35 percent.	Moderate bearing capacity; moderate compressibility.	Slight to severe, depending on slope.
Rockiness; unstable slopes	Rockiness; high erodibility; unstable slopes.	Rockiness; high erodibility.	Bedrock at depth of 1½ to 3 feet; moderate bearing capacity; moderate compressibility.	Severe: bedrock at depth of 1½ to 3 feet.
Low density if compacted; high compressibility; high organic-matter content; slopes up to 35 percent.	Slopes up to 35 percent	Slopes up to 35 percent	Low bearing capacity; high compressibility; high organic-matter content.	Severe: bedrock at depth of 1½ to 3½ feet.
Poor workability; low density if compacted; high organic-matter content; high compressibility; stoniness in places.	Poor workability; continuous wetness; stoniness in places.	Poor workability; continuous wetness; stoniness in places.	Low bearing capacity; high compressibility; low shear strength; subject to sliding; high shrinkage; high organic-matter content.	Slight to severe, depending on slope; bedrock at depth of 1½ to 3 feet in places.
Stoniness; low density if compacted; high organic-matter content; high compressibility.	Stoniness; bedrock at depth of 1½ to 2½ feet; poor workability.	Stoniness; bedrock at depth of 1½ to 2½ feet; poor workability.	Bedrock at depth of 1½ to 2½ feet; low bearing capacity; high compressibility; low shear strength; high organic-matter content.	Severe: bedrock at depth of 1½ to 2½ feet.

TABLE 3.—*Engineering*

Soil series and map symbols	Suitability as source of—		Soil features affecting—	
	Topsoil	Road fill	Highway location	Farm ponds: Reservoir area
Ookala: OoC, OoD, OoE.	Good	Poor: high compressibility; low density if compacted; high organic-matter content.	Low bearing capacity; high compressibility; slopes up to 35 percent	High seepage loss; slopes up to 35 percent.
Opihikao: rOPE	Poor: pahoehoe lava at depth of less than 10 inches.	Poor: pahoehoe lava at depth of less than 10 inches.	Pahoehoe lava at depth of less than 10 inches.	Pahoehoe lava at depth of less than 10 inches.
Paauhau: PaC, PaD, PaE.	Good	Poor: high compressibility; low density if compacted; high organic-matter content.	Low bearing capacity; high compressibility; slopes up to 35 percent.	High seepage loss; slopes up to 35 percent.
Pakini: PKB	Good	Fair: high erodibility	High erodibility	High seepage loss
Palapalai: PLC, PMC	Good	Fair: moderate compressibility.	Moderate compressibility; high erodibility; moderate bearing capacity.	High seepage loss
Panaewa: PeC	Poor: bedrock at depth of less than 1½ feet; irreversible dehydration into gravel-size aggregates; continuous wetness.	Poor: bedrock at depth of less than 1½ feet; high compressibility; low density if compacted; poor workability; continuous wetness; high organic-matter content.	Bedrock at depth of less than 1½ feet; high compressibility; low bearing capacity; continuous wetness.	High seepage loss
Papai: rPAE	Poor: fragmental Aa lava at depth of less than 10 inches.	Poor: mucky surface layer.	Fragmental Aa lava at depth of less than 10 inches.	Fragmental Aa lava at depth of less than 10 inches.
Piihonua: PND, POD	Poor to fair: continuous wetness; irreversible dehydration into gravel-size aggregates; stoniness in places.	Poor: high compressibility; low density if compacted; poor workability; continuous wetness; stoniness in places; high organic-matter content.	Low bearing capacity; high compressibility; continuous wetness; stoniness in places.	High seepage loss: stoniness in places.
Puaulu: PPC	Poor to fair: continuous wetness; irreversible dehydration into gravel-size aggregates.	Poor: high compressibility; low density if compacted; poor workability; continuous wetness; high organic-matter content.	Low bearing capacity; high compressibility; continuous wetness.	High seepage loss
Puhimau: rPHB	Good	Poor: bedrock at depth of 1 to 1½ feet; high compressibility.	Bedrock at depth of 1 to 1½ feet; low bearing capacity; high compressibility.	High seepage loss

interpretations—Continued

Soil features affecting—Continued				Degree and kind of limitations for septic tank filter fields
Farm ponds—Continued: Embankment	Terraces and diversions	Grassed waterways	Foundations for low buildings	
Low density if compacted; high compressibility; high organic-matter content; slopes up to 35 percent.	Slopes up to 35 percent	Slopes up to 35 percent	Low bearing capacity; high compressibility; high organic-matter content.	Slight to severe, depending on slope.
Pahoehoe lava at depth of less than 10 inches.			Pahoehoe lava at depth of less than 10 inches.	Severe: pahoehoe lava at depth of less than 10 inches.
Low density if compacted; high compressibility; high organic-matter content.	Slopes up to 35 percent	Slopes up to 35 percent	Low bearing capacity; high compressibility; high organic-matter content.	Slight to severe, depending on slope.
High erodibility; unstable slopes; subject to piping.	High erodibility; unstable slopes.	High erodibility; plants difficult to establish.	Moderate compressibility; moderate shear strength; moderate bearing capacity.	Moderate: bedrock at depth of 3½ to 6 feet.
High erodibility; unstable slopes; moderate compressibility; low density if compacted.	Low density if compacted; unstable slopes.	Unstable slopes	Moderate compressibility; moderate bearing capacity.	Moderate: bedrock at depth of 4 to 6 feet.
High compressibility; low density if compacted; high organic-matter content.	Rockiness; bedrock at depth of less than 1½ feet; poor workability.	Rockiness; bedrock at depth of less than 1½ feet; poor workability.	Bedrock at depth of less than 1½ feet; high compressibility; low bearing capacity; low shear strength; high organic-matter content.	Severe: bedrock at depth of less than 1½ feet.
Fragmental Aa lava at depth of less than 10 inches.			Fragmental Aa lava at depth of less than 10 inches.	Severe: fragmental Aa lava at depth of less than 10 inches.
Poor workability; low density if compacted; high organic-matter content; high compressibility; stoniness in places.	Poor workability; continuous wetness; stoniness in places.	Poor workability; continuous wetness; stoniness in places.	Low bearing capacity; high compressibility; low shear strength; subject to sliding; high organic-matter content.	Moderate to severe, depending on slope; bedrock at depth of 3½ to 6 feet.
Poor workability; low density if compacted; high organic-matter content; high compressibility.	Poor workability; continuous wetness.	Poor workability; continuous wetness.	Low bearing capacity; high compressibility; low shear strength; high organic-matter content.	Slight to moderate, depending on slope.
Limited volume of material; low density if compacted; high compressibility; subject to piping.	Bedrock at depth of 1 to 1½ feet; poor workability.	Bedrock at depth of 1 to 1½ feet; poor workability.	Bedrock at depth of 1 to 1½ feet; high compressibility.	Severe: bedrock at depth of 1 to 1½ feet.

424-785—73——7

TABLE 3.—*Engineering*

Soil series and map symbols	Suitability as source of—		Soil features affecting—	
	Topsoil	Road fill	Highway location	Farm ponds: Reservoir area
Puna: rPXE	Poor: fragmental Aa lava at depth of less than 10 inches.	Poor: mucky surface layer.	Fragmental Aa lava at depth of less than 10 inches.	Fragmental Aa lava at depth of less than 10 inches.
Punaluu: rPYD	Poor: pahoehoe lava at depth of less than 10 inches.	Poor: pahoehoe lava at depth of less than 10 inches.	Pahoehoe lava at depth of less than 10 inches.	Pahoehoe lava at depth of less than 10 inches.
Punohu: PRD	Good	Poor: high compressibility; low density if compacted; high organic-matter content.	Low bearing capacity; high compressibility.	High seepage loss
Puukala: PSC, PTC	Poor: stoniness; bedrock at depth of 1 to 1½ feet; rockiness in places.	Poor: bedrock at depth of 1 to 1½ feet; high organic-matter content.	Bedrock at depth of 1 to 1½ feet; low bearing capacity; high compressibility; stoniness; rockiness in places.	High seepage loss; stoniness; rockiness in places.
Puu Oo: PUC	Good	Poor: high compressibility; low density if compacted; high organic-matter content.	Low bearing capacity; high compressibility.	High seepage loss
Puu Pa: PVD, PVF3	Poor: stoniness; fragmental Aa lava at depth of 1½ to 4 feet.	Fair: high erodibility; unstable slopes; stoniness.	Stoniness; high erodibility; unstable slopes; slopes up to 100 percent.	Stoniness; high seepage loss.
Puu Pa: PWD	Good	Fair: high erodibility; unstable slopes.	High erodibility; unstable slopes.	High seepage loss
Rock land: rRO	Poor: rockiness; bedrock at depth of less than 1 foot.	Poor: rockiness; bedrock at depth of less than 1 foot.	Rockiness	
Rough broken land: RB.	Poor: very steep slopes; bedrock at variable depth.	Poor: very steep slopes; variable properties.	Very steep slopes	
Tropofolists. Soils are less than 12 inches deep over lava.				
Tropaquepts: Tr	Poor: water table at depth of 0 to 1½ feet.	Poor: water table at depth of 0 to 1½ feet.	Water table at depth of 0 to 1½ feet.	Water table at depth of 0 to 1½ feet.

interpretations—Continued

Soil features affecting—Continued				Degree and kind of limitations for septic tank filter fields
Farm ponds—Continued: Embankment	Terraces and diversions	Grassed waterways	Foundations for low buildings	
Fragmental Aa lava at depth of less than 10 inches.			Fragmental Aa lava at depth of less than 10 inches.	Severe: fragmental Aa lava at depth of less than 10 inches.
Pahoehoe lava at depth of less than 10 inches.			Pahoehoe lava at depth of less than 10 inches.	Severe: pahoehoe lava at depth of less than 10 inches.
Low density if compacted; high compressibility; high organic-matter content.	Fair workability	Fair workability	Low bearing capacity; high compressibility; low shear strength; high organic-matter content.	Severe: slopes up to 20 percent.
Limited volume of material; high compressibility; low density if compacted; high organic-matter content; rockiness in places.	Stoniness; bedrock at depth of 1 to 1½ feet; rockiness in places.	Stoniness; bedrock at depth of 1 to 1½ feet; poor workability; rockiness in places.	Low bearing capacity; high compressibility; low shear strength; bedrock at depth of 1 to 1½ feet; high organic-matter content.	Severe: bedrock at depth of 1 to 1½ feet.
Low density if compacted; high compressibility; high organic-matter content.	Poor workability	Poor workability	Low bearing capacity; high compressibility; low shear strength; subject to sliding; high organic-matter content.	Moderate: slopes up to 12 percent.
Stoniness; moderate density if compacted; unstable slopes; subject to piping.	Stoniness; high erodibility; unstable slopes.	Stoniness; high erodibility; plants difficult to establish.	Bedrock at depth of 1½ to 4 feet.	Moderate to severe: slopes up to 100 percent; bedrock at depth of 1½ to 4 feet.
Moderate density if compacted; unstable slopes; high erodibility; subject to piping.	High erodibility; unstable slopes.	High erodibility; droughtiness; plants difficult to establish.	Bedrock at depth of 4 to 5 feet.	Severe: slopes up to 20 percent.
			Rockiness; bedrock at depth of less than 1 foot.	Severe: bedrock at depth of less than 1 foot.
			Very steep slopes	Severe: very steep slopes.
Water table at depth of 0 to 1½ feet.			Water table at depth of 0 to 1½ feet; subject to flooding.	Severe: water table at depth of 0 to 1½ feet; subject to flooding.

TABLE 3.—*Engineering*

Soil series and map symbols	Suitability as source of—		Soil features affecting—	
	Topsoil	Road fill	Highway location	Farm ponds: Reservoir area
Umikoa: UMD, USD	Good (UMD), fair (USD): stoniness in places.	Fair: moderate compressibility; unstable slopes; moderate density if compacted; stoniness in places; high organic-matter content.	Moderate bearing capacity; instability on steep slopes; stoniness in places.	High seepage loss
Very stony land: rVS	Poor: stoniness	Good as stone fill	Stoniness	
Waiaha: WAC, WHC	Poor: stoniness; bedrock at depth of less than 1½ feet. WAC has nonstony surface layer.	Fair: bedrock at depth of less than 1½ feet; high erodibility.	Bedrock at depth of less than 1½ feet; unstable slopes; high erodibility.	High seepage loss
Waiaha: WKD	Poor: rockiness; bedrock at depth of less than 1½ feet.	Poor: bedrock at depth of less than 1½ feet.	Rockiness; bedrock at depth of less than 1½ feet; unstable slopes; high erodibility.	Rockiness; bedrock at depth of less than 1½ feet; high seepage loss.
Waiaha: WAD	Poor: bedrock at depth of less than 1½ feet.	Poor: bedrock at depth of less than 1½ feet.	Bedrock at depth of less than 1½ feet; unstable slopes; high erodibility.	Bedrock at depth of less than 1½ feet; high seepage loss.
Waikaloa: WLC	Good	Fair: high erodibility on slopes.	High erodibility; unstable slopes.	High seepage loss
Waimea: WMC, WSD	Good (WMC), fair (WSD): stoniness in places.	Fair: high erodibility; stoniness in places.	High erodibility; unstable slopes; stoniness in places.	High seepage loss; stoniness in places.

interpretations—Continued

Soil features affecting—Continued				Degree and kind of limitations for septic tank filter fields
Farm ponds—Continued	Terraces and diversions	Grassed waterways	Foundations for low buildings	
Embankment				
High organic-matter content; moderate density if compacted; unstable slopes; stoniness in places.	Unstable slopes; high erodibility; stoniness in places.	Stoniness in places	Moderate compressibility; high organic-matter content.	Severe: slopes up to 20 percent.
Stoniness			Stoniness	Severe: bedrock at variable depth.
Limited volume of material; stoniness; unstable slopes; high erodibility; subject to piping.	Bedrock at depth of less than 1½ feet; stoniness; high erodibility; unstable slopes.	Bedrock at depth of less than 1½ feet; stoniness; high erodibility.	Bedrock at depth of less than 1½ feet.	Severe: bedrock at depth of less than 1½ feet.
Rockiness; limited volume of material; unstable slopes; high erodibility; subject to piping.	Rockiness; bedrock at depth of less than 1½ feet; high erodibility; unstable slopes.	Rockiness; bedrock at depth of less than 1½ feet; high erodibility; droughtiness.	Bedrock at depth of less than 1½ feet.	Severe: bedrock at depth of less than 1½ feet.
Limited volume of material; unstable slopes; high erodibility; subject to piping.	Bedrock at depth of less than 1½ feet; high erodibility; unstable slopes.	Bedrock at depth of less than 1½ feet; high erodibility; droughtiness.	Bedrock at depth of less than 1½ feet.	Severe: bedrock at depth of less than 1½ feet.
High erodibility; unstable slopes; subject to piping.	High erodibility; unstable slopes.	High erodibility; plants difficult to establish.	Moderate compressibility; moderate shear strength; moderate bearing capacity.	Moderate: slopes up to 12 percent.
High erodibility; unstable slopes; subject to piping; stoniness in places.	High erodibility; unstable slopes; stoniness in places.	High erodibility; plants difficult to establish; stoniness in places.	Moderate compressibility; moderate shear strength; moderate bearing capacity.	Moderate to severe, depending on slope.

TABLE 4.—*Engineering test data*

[Tests made by Soil Survey Laboratory, SCS, Riverside, California, except as indicated in footnotes]

Soil name and location	Parent material	Report number	Depth	Liquid limit	Plasticity index	Unified classification
			Inches	*Percent*		
Apakuie very fine sandy loam: Lat. 19°54'30" N. and long. 155°23'30" E.	Volcanic ash.	659	0–4	([1] [2])	([2])	ML.
		6512	16–26	([2])	([2])	ML.
Kawaihae extremely stony very fine sandy loam: Lat. 20°4'10" N. and long. 155°50'10" E.	Volcanic ash.	6542	0–3	43	12	ML.
		6543	3–13	41	9	ML.
		6545	24–36	([2])	([2])	ML.
Kohala silty clay: Lat. 20°14'30" N. and long. 155°49'50" E.	Volcanic ash.	6567	0–7	[1] 59	24	MH.
		6569	14–27	67	26	MH.
		6572	45–53	([2])	([2])	MH.
Maile silt loam: Lat. 19°59'10" N. and long. 155°23'10" E.	Volcanic ash.	65100	0–4	([1] [2])	([2])	OH.
		65101	14–29	240	26	MH–OH.
		6596	24–29	190	32	MH–OH.
		6598	36–48	280	54	MH–OH.
Naalehu silty clay loam: Lat. 19°3'15" N. and long. 155°35'30" E.	Volcanic ash.	65108	0–20	[1] 73	21	MH–OH.
		65110	31–36	120	25	MH–OH.
		65112	53–65	([2])	([2])	MH–OH.
Waimea very fine sandy loam: 5.4 miles northwest of Kamuela Post Office and 0.5 mile east of Kohala Mountain road.	Volcanic ash.	[3] 774	0–8	([2])	([2])	ML.
		775	14–25	82	7	MH.

[1] These samples were not allowed to dry but were tested beginning at natural moisture content.
[2] Nonplastic.
[3] Tests performed by the Bureau of Public Roads.

Order—There are 10 orders: Entisols, Vertisols, Inceptisols, Aridisols, Mollisols, Spodosols, Alfisols, Ultisols, Oxisols, and Histosols. Only five orders are represented on the Island of Hawaii. They are Aridisols, Entisols, Histosols, Inceptisols, and Mollisols. Most of the soils are Inceptisols. Soils of the following series are Histosols: Kahaluu, Kaimu, Keaukaha, Keei, Kekake, Kiloa, Kona, Lalaau, Malama, Mawae, Opihikao, Papai, Puna, and Punaluu. The other orders are represented by only one series each. They are: Aridisols—Kawaihae series, Entisols—Kilauea series, and Mollisols—Mahukona series.

An order represents the kind and the relative strength of the soil-forming process. Although it does not correspond exactly with any other category in any other classification system, each order is made up of certain well-recognized groups of soils.

Entisols, for example, are recent soils and very steep soils that lack distinctive horizons. *Vertisols* are dark-colored clayey soils that swell and soils formerly classified as Tropical Black Earths. *Inceptisols* are soils that are on young but not recent land surfaces and have weakly developed horizons. *Aridisols* are soils that are usually dry. *Mollisols* are grassland soils of subhumid regions that have a thick, dark-colored, well-structured surface layer. *Spodosols* are Podzols and hydromorphic soils. *Alfisols* are timbered soils, other than Podzols, of subhumid regions. *Ultisols* are timbered soils, other than Podzols, of humid regions. *Oxisols* are very strongly weathered soils and soils on very old tropical landscapes. *Histosols* are organic soils.

Suborder.—An order is so broad that the soils in it have similar morphology but little or no genetic relationship. Criteria used to divide orders into suborders were chosen to produce categories of greater genetic homogeneity. For example, most orders contain well-drained soils and their associated poorly drained soils. The criteria for suborders reflect the absence or presence of wetness or differences in climate or vegetation.

Great group.—Each suborder is divided into great groups on the basis of uniformity in kind and sequence of genetic horizons, on base saturation, or on properties related to climate. Each great group, therefore, is uniform in kind and arrangement of genetic horizons and features, and each is within a relatively narrow range of climate. Brief definitions of genetic horizons and such terms as "base saturation" are given in the Glossary.

Subgroup.—Each great group is divided into subgroups, one representing the central (typic) concept of the subgroup, and others, called intergrades, representing soils that have mostly the properties of one great group but also have one or more properties of another great group, suborder, or order. For example, if soils in a great group of the order Inceptisols were considered to be intergrades toward the order Histosols, they would be classified in a *Histic* subgroup of the great group.

TABLE 5.—*Classification of soil series by higher categories*

Series	Current classification		1938 classification
	Family	Subgroup	Great soil group
Ainakea	Fine, oxidic, isothermic	Andic Humitropepts	Humic Latosols.
Akaka	Thixotropic, isomesic	Typic Hydrandepts	Hydrol Humic Latosols.
Alapai	Thixotropic, isothermic	Typic Hydrandepts	Hydrol Humic Latosols.
Amalu	Fine, mixed, acid, isomesic	Histic Placaquepts	Hydrol Humic Latosols.
Apakuie	Medial over cindery isomesic	Typic Vitrandepts	Latosolic Brown Forest.
Hanipoe	Medial, isomesic	Typic Dystrandepts	Latosolic Brown Forest.
Hawi	Fine, halloysitic, isohyperthermic	Typic Ustropepts	Low Humic Latosols.
Heake	Medial, isothermic	Lithic Dystrandepts	Regosols.
Hilea	Thixotropic, isothermic	Lithic Hydrandepts	Hydrol Humic Latosols.
Hilo	Thixotropic, isohyperthermic	Typic Hydrandepts	Hydrol Humic Latosols.
Honaunau	Thixotropic, isothermic	Typic Hydrandepts	Hydrol Humic Latosols.
Honokaa	Thixotropic, isothermic	Typic Hydrandepts	Hydrol Humic Latosols.
Honuaulu	Thixotropic over fragmental, isothermic	Hydric Dystrandepts	Humic Latosols.
Huikau	Medial over cindery, isomesic	Typic Vitrandepts	Regosols.
Kaalualu	Medial over fragmental, isohyperthermic	Ustollic Eutrandepts	Reddish Brown.
Kahaluu	Dysic, isomesic	Lithic Tropofolists	Lithosols.
Kahua	Thixotropic, isomesic	Typic Placandepts	Hydrol Humic Latosols.
Kaimu	Euic, isohyperthermic	Typic Tropofolists	Lithosols.
Kainaliu	Medial over fragmental, isohyperthermic	Typic Eutrandepts	Humic Latosols.
Kaiwiki	Thixotropic, isothermic	Typic Hydrandepts	Hydrol Humic Latosols.
Kamakoa	Medial, isothermic	Mollic Vitrandepts	Alluvial.
Kamaoa	Medial, isothermic	Typic Eutrandepts	Reddish Prairie.
Kapapala	Medial, isomesic	Typic Dystrandepts	Latosolic Brown Forest.
Kawaihae	Medial, ashy, isohyperthermic	Ustollic Camborthids	Red Desert.
Kealakekua	Thixotropic, isothermic	Typic Hydrandepts	Hydrol Humic Latosols.
Keaukaha	Dysic, isohyperthermic	Lithic Tropofolists	Lithosols.
Keei	Dysic, isothermic	Lithic Tropofolists	Lithosols.
Keekee	Medial, isomesic	Mollic Vitrandepts	Alluvial.
Kehena	Thixotropic, acid, isothermic	Aeric Andaquepts	Humic Latosols.
Kekake	Dysic, isomesic	Lithic Tropofolists	Lithosols.
Kikoni	Medial, isothermic	Typic Eutrandepts	Reddish Prairie.
Kilauea	Sandy-skeletal, ashy, isothermic	Typic Ustorthents	Regosols.
Kiloa	Dysic, isothermic	Typic Tropofolists	Lithosols.
Kilohana	Medial, isomesic	Mollic Vitrandepts	Regosols.
Kohala	Very fine, mixed, halloysitic, isohyperthermic	Ustic Humitropepts	Low Humic Latosols.
Kona	Euic, isothermic	Lithic Tropofolists	Lithosols.
Kukaiau	Thixotropic, isothermic	Hydric Dystrandepts	Humic Latosols.
Lalaau	Dysic, isomesic	Typic Tropofolists	Lithosols.
Laumaia	Medial, isomesic	Typic Dystrandepts	Latosolic Brown Forest.
Mahukona	Fine, halloysitic, isohyperthermic	Aridic Haplustolls	Low Humic Latosols.
Maile	Thixotropic, isomesic	Hydric Dystrandepts	Latosolic Brown Forest.
Malama	Dysic, isohyperthermic	Typic Tropofolists	Lithosols.
Manahaa	Thixotropic, isomesic	Hydric Dystrandepts	Latosolic Brown Forest.
Manu	Medial, isothermic	Hydric Dystrandepts	Regosols.
Mawae	Euic, isomesic	Typic Tropofolists	Lithosols.
Moaula	Thixotropic, isothermic	Hydric Dystrandepts	Humic Latosols.
Naalehu	Medial, isohyperthermic	Typic Eutrandepts	Reddish Prairie.
Niulii	Thixotropic, isothermic	Hydric Dystrandepts	Humic Latosols.
Ohia	Thixotropic, isothermic	Typic Hydrandepts	Hydrol Humic Latosols.
Olaa	Thixotropic over fragmental, isohyperthermic	Typic Hydrandepts	Hydrol Humic Latosols.
Ookala	Thixotropic, isohyperthermic	Hydric Dystrandepts	Humic Latosols.
Opihikao	Dysic, isohyperthermic	Lithic Tropofolists	Lithosols.
Paauhau	Thixotropic, isohyperthermic	Hydric Dystrandepts	Humic Latosols.
Pakini	Medial, isohyperthermic	Entic Eutrandepts	Reddish Brown.
Palapalai	Medial, isothermic	Typic Eutrandepts	Reddish Prairie.
Panaewa	Thixotropic, isohyperthermic	Lithic Hydrandepts	Hydrol Humic Latosols.
Papai	Euic, isohyperthermic	Typic Tropofolists	Lithosols.
Piihonua	Thixotropic, isomesic	Typic Hydrandepts	Latosolic Brown Forest.
Puaulu	Medial over thixotropic, isomesic	Typic Hydrandepts	Regosols.
Puhimau	Medial, isothermic	Hydric Lithic Dystrandepts	Regosols.
Puna	Euic, isothermic	Typic Tropofolists	Lithosols.
Punaluu	Euic, isohyperthermic	Lithic Tropofolists	Lithosols.
Punohu	Thixotropic, isomesic	Hydric Dystrandepts	Latosolic Brown Forest.
Puukala	Thixotropic, isomesic	Hydric Lithic Dystrandepts	Latosolic Brown Forest.
Puu Oo	Thixotropic, isomesic	Hydric Dystrandepts	Latosolic Brown Forest.
Puu Pa	Medial over fragmental, isothermic	Ustollic Eutrandepts	Reddish Brown.
Umikoa	Medial, isomesic	Typic Dystrandepts	Latosolic Brown Forest.
Waiaha	Medial, isohyperthermic	Lithic Eutrandepts	Reddish Brown.
Waikaloa	Medial, isothermic	Ustollic Eutrandepts	Reddish Brown.
Waimea	Medial, isothermic	Typic Eutrandepts	Reddish Prairie.

Several subgroups, particularly in the order Inceptisols, correspond approximately to soil families according to the classification by Cline (*5*).

Family.—Families are established within a subgroup on the basis of properties important to the growth of plants or the behavoir of soils when they are used for engineering. Among the properties considered are texture, mineral composition, reaction, soil temperature, permeability, thickness of horizons, and consistence.

Names of soil families consist of a series of properties used with the subgroup name. For example, the Waimea soils are classified in the medial, isothermic family of Typic Eutrandepts. The following list shows the criteria used for classifying soils on the island in families and gives definitions of the class names:

Class name	*Definition*
Ashy	More than 60 percent (by weight) consists of volcanic ash, cinders, or pumice, and less than 35 percent (by volume) is 2 millimeters across or larger, and apparent texture after prolonged rubbing is sandy.
Ashy-skeletal	Rock fragments more than 2 millimeters across make up 35 percent or more by volume, and the fine earth fraction is as defined for ashy.
Fine	Clay portion constitutes 35 to 60 percent clay in the fine earth fraction.
Medial	Term used when the soil consists of a mixture of discrete mineral particles and gels, and there is less than 60 percent (by weight) volcanic ash, cinders, and pumice in the fine earth; less than 35 percent (by volume) is 2 millimeters across or larger, and the fine earth is not thixotropic, and apparent texture after prolonged rubbing is loamy.
Cindery	More than 60 percent (by weight) consists of volcanic ash, cinders, and pumice, and 35 percent or more (by volume) is 2 millimeters across or larger.
Medial over cindery.	Medial material over cindery material.
Medial over fragmental.	Medial material over fragmental Aa lava.
Medial over thixotropic.	Medial material over smeary material.
Thixotropic	A reversible gel-sol transformation under isothermal shearing stress following rest. Thixotropic properties are exhibited by smeariness in the field.
Thixotropic over fragmental.	Smeary material over fragmental Aa lava.

TABLE 6.—*Chemical and physical*

[Analysis made by Soil Survey Laboratories, SCS, Lincoln, Nebraska, and Riverside, California,

Soil and sample number	Horizon	Depth	Organic carbon	Nitrogen	C/N ratio	Extractable iron (Fe)	Bulk density [1]	Moisture retention [1]		Reaction		Cation exchange capacity (NH_4 OAc)
								⅓ atmos.	15 atmos.	1:5 (H_2O)	1:5 (KCL)	
Apakuie very fine sandy loam:												
S65Ha-1-14		*In.*	*Pct.*	*Pct.*		*Pct.*	*Gm./cc.*	*Pct.*	*Pct.*	*pH*	*pH*	*Meq./100 gm.*
RSL 6514	A1	0–2	14. 22	1. 040	14	5. 4	------	80. 92	43. 29	6. 7	5. 8	51. 2
RSL 6515	B2	2–8	6. 48	. 555	12	8. 3	------	65. 17	46. 87	6. 3	5. 5	39. 0
RSL 6516	IIAb	8–15	5. 48	. 408	13	6. 2	------	63. 81	46. 95	6. 4	5. 6	37. 3
RSL 6517	IIC1	15–30	3. 17	. 236	13	5. 0	------	49. 82	41. 21	6. 6	5. 7	25. 3
RSL 6518	IIC2	30–50	1. 44	. 104	14	3. 7	------	32. 61	23. 98	6. 6	5. 6	13. 4
Honokaa silty clay loam:												
S62Ha-1-1												
LSL 17356	Ap	0–7	11. 70	. 899	13	16. 1	0. 51	133. 4	101. 9	5. 4	4. 5	53. 1
LSL 17357	B21	7–14	6. 55	. 447	15	16. 0	. 34	191. 6	154. 5	5. 2	4. 5	33. 7
LSL 17358	B22	14–20	9. 36	. 438	21	13. 6	. 31	212. 0	166. 9	5. 4	4. 7	39. 3
LSL 17359	B23	20–25	8. 49	. 432	20	14. 8	. 28	229. 3	196. 0	5. 4	5. 0	29. 9
LSL 17360	B24	25–28	7. 80	. 392	20	15. 1	. 25	244. 8	193. 9	5. 5	5. 2	25. 3
LSL 17361	B25	28–32	7. 01	. 352	20	13. 7	. 29	232. 0	187. 5	5. 6	5. 4	24. 3
LSL 17362	C	32–34	5. 14	. 206	25	16. 1	. 29	200. 3	165. 8	5. 7	5. 6	23. 0
LSL 17363	B27	39–45	4. 92	. 294	17	18. 7	. 26	267. 5	211. 1	5. 5	5. 3	21. 2
LSL 17364	B210	59–65	3. 33	. 312	11	21. 5	. 28	263. 8	199. 6	5. 2	5. 1	14. 4

See footnotes at end of table.

Isohyperthermic ---- Soils that have less than 5° C. (9° F.) difference between mean summer and mean winter temperature and a mean annual soil temperature of more than 22° C. (72° F.).

Isothermic ---- Soils that have less than 5° C. (9° F.) difference between mean summer and mean winter temperature, and a mean annual soil temperature between 15° and 22° C. (59° and 72° F.).

Isomesic ------ Soils that have less than 5° C. (9° F.) difference between mean summer and mean winter temperature and a mean annual soil temperature between 8° and 15° C. (47° and 59° F.).

Acid --------- A pH less than 5.0 in 0.01 $MCaCl_2$ (1:1) throughout the control section (about 5.5 in H_2O, 1:1).

Dysic --------- A pH less than 4.5 (in 0.01M $CaCl_2$) in all parts of the control section of a Histosol.

Euic ---------- A pH of undried sample is 4.5 or more (in 0.01M $CaCl_2$) in at least some part of the organic materials in the control section of a Histosol.

Kaolinitic ----- More than half by weight consists of kaolinite, dickite, nacrite, tabular halloysite, and smaller amounts of other 1:1 or nonexpanding 2:1 minerals or gibbsite.

Mixed -------- Mixed clay mineralogy that contains less than 40 percent of any one mineral other than quartz.

Oxidic -------- Less than 90 percent quartz or less than 40 percent of any single mineral and the ratio of:

$$\frac{\text{percent extractable iron oxide and gibbsite}}{\text{percent clay}} \geq 0.20$$

Series.—Classification of soils in series is described in the section "How This Survey Was Made," and each soil series is described in "Descriptions of the Soils."

Laboratory Analysis of the Soils

Table 6 contains analytical data for eight representative soil series in the survey area. Each of the soil series was sampled at two locations, but the data presented is for only one of the locations. All samples were collected from carefully selected pits. Soil fragments larger than 1 inch across were discarded in the field. Fragments larger than 2 millimeters across were discarded in the laboratory. Soil samples were kept moist, but all capacity measurements are reported on an oven-dry basis.

The content of organic carbon was determined by wet combustion using the Walkley-Black method (1 milliequivalent $K_2Cr_2O_7$ equivalent to 3.9 milligrams carbon) (*10*).

Total nitrogen was determined by the Kjeldahl method modified by the Association of Official Agricultural Chemists (*3*).

analysis of selected soils

except as otherwise indicated in footnotes. Dashed line indicates data was not determined]

Extractable bases (Meq./100 gm.)				Base saturation (NH_4OAc)	Total analysis [2]											
Ca	Mg	Na	K		SiO_2	TiO_2	Al_2O	Fe	MnO	MgO	CaO	Na_2O	K_2O	P_2O	LOI	$H_2O(-)$
				Pct.	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*
21.6	3.6	0.1	1.8	53	23.98	3.08	16.44	11.16	0.35	1.87	2.78	1.39	0.48	1.92	24.14	10.42
11.9	2.2	.2	.5	38	22.18	3.83	19.46	14.24	.30	3.58	2.42	1.38	.48	.94	17.16	14.48
11.5	1.4	.2	.4	36	34.80	3.44	21.21	12.59	.24	5.50	4.91	2.84	.74	.80	6.48	7.02
8.8	1.0	.2	.4	41	21.98	3.33	21.08	14.93	.42	1.63	2.66	1.59	.50	1.16	17.98	13.92
3.9	.4	.2	.4	36	28.50	3.25	20.88	14.39	.26	4.81	3.36	2.00	.51	.66	11.36	11.06
9.4	2.6	.3	.5	24	10.66	3.84	14.25	18.90	.18	.16	.14	.91	.58	.74	31.88	18.20
.8	.3	.2	.2	4	9.62	3.63	16.20	19.12	.18	.19	.06	.04	.55	.50	28.28	21.53
.5	.3	.2	.1	3	9.45	3.54	19.39	15.36	.13	.23	.00	.02	.36	.68	29.41	21.12
------	.1	.2	.1	1	8.11	3.68	18.47	16.49	.14	.21	.00	(3)	.29	.74	28.28	22.96
------	1.2	.1	.2	6	8.54	3.37	19.02	15.99	.16	.07	.00	.00	.27	.75	28.91	22.21
------	.6	.1	.1	3	9.33	2.98	23.70	12.83	.15	.15	.00	.00	.20	.08	28.33	22.82
------	.4	.2	.1	3	8.46	3.51	24.16	15.15	.15	.17	.00	.00	.11	.06	25.96	22.52
------	.7	.1	.2	5	8.17	4.29	19.14	21.54	.08	.18	.00	.00	.33	.06	26.20	20.01
------	.6	.2	.2	7	10.85	3.77	18.75	24.49	.04	(3)	.00	.08	.59	.04	24.83	17.54

424-785—73——8

TABLE 6.—*Chemical and physical*

Soil and sample number	Horizon	Depth	Organic carbon	Nitrogen	C/N ratio	Extractable iron (Fe)	Bulk density [1]	Moisture retention [1]		Reaction		Cation exchange capacity (NH_4 OAc)
								⅓ atmos.	15 atmos.	1:5 (H_2O)	1:5 (KCL)	
Kawaihae very fine sandy loam:												
S65Ha-1-6		*In.*	*Pct.*	*Pct.*	*Pct.*		*Gm./cc.*	*Pct.*	*Pct.*	*pH*	*pH*	*Meq./100 gm.*
RSL 6546	A1	0-2	. 41	. 051	8	9. 6	------	28. 56	18. 66	7. 1	6. 1	19. 9
RSL 6547	B21	2-16	. 61	. 057	11	10. 7	------	40. 28	19. 25	6. 5	5. 7	15. 5
RSL 6548	C1	16-24	. 61	. 052	12	11. 6	------	37. 46	23. 30	7. 0	6. 3	16. 3
RSL 6549	C2	24-33	. 70	. 059	12	14. 3	------	39. 82	24. 44	7. 3	6. 2	14. 6
Kealakekua silty clay loam:												
S62Ha-1-3												
LSL 17376	Ap1	0-4	17. 10	1. 200	14	9. 7	. 27	138. 5	99. 8	6. 1	5. 0	55. 7
LSL 17377	Ap2	4-6	11. 40	. 855	13	15. 4	. 39	153. 4	103. 9	6. 0	4. 9	60. 5
LSL 17378	B21	6-10	7. 26	. 604	12	20. 2	. 34	153. 5	113. 1	5. 7	4. 6	------
LSL 17379	B22	10-20	6. 24	. 541	12	21. 6	. 32	174. 0	127. 7	5. 4	4. 7	34. 8
LSL 17380	B23	20-23	9. 25	. 537	17	12. 4	. 35	221. 9	166. 3	5. 6	5. 0	34. 0
LSL 17381	B24	23-26	6. 47	. 428	15	6. 9	. 32	235. 4	174. 0	5. 8	5. 4	30. 5
Kohala silty clay:												
S65Ha-1-3												
RSL 6567	Ap1	0-7	2. 68	. 255	11	14. 8	1. 22	35. 04	28. 17	5. 6	4. 9	32. 3
RSL 6568	Ap2	7-14	2. 40	. 241	10	15. 0	1. 17	33. 63	27. 55	5. 6	5. 0	34. 4
RSL 6569	B21	14-27	. 97	. 149	7	17. 5	1. 19	37. 52	28. 85	6. 1	5. 6	23. 8
RSL 6570	B22	27-39	. 66	. 101	7	21. 5	1. 32	33. 08	28. 75	6. 1	5. 8	19. 1
RSL 6571	C1	39-45	. 80	. 077	10	18. 0	1. 15	40. 51	30. 94	6. 5	5. 9	27. 4
RSL 6572	C2	45-53	------	------	------	9. 5	------	44. 05	28. 55	6. 6	5. 9	31. 6
Naalehu silty clay loam:												
S65Ha-1-11												
RSL 65108	Ap	0-20	3. 29	. 252	13	5. 9	. 87	49. 24	34. 88	5. 4	4. 5	45. 8
RSL 65109	B21	20-31	1. 97	. 170	12	7. 5	. 85	53. 09	39. 54	5. 8	4. 8	50. 2
RSL 65110	IIB22	31-36	. 90	. 083	11	9. 2	. 79	87. 30	73. 18	6. 6	5. 6	63. 1
RSL 65111	IIIB23	36-53	60	057	11	9. 7	. 46	121. 21	98. 90	6. 7	5. 6	63. 6
RSL 65112	IVC	53-65	. 47	------	------	7. 9	. 51	100. 60	78. 73	6. 6	5. 7	67. 6
Pakini very fine sandy loam:												
S65Ha-1-9												
RSL 65131	Ap	0-3	5. 30	. 474	11	4. 4	. 82	50. 90	29. 54	6. 7	5. 7	51. 0
RSL 65132	A12	3-8	3. 89	. 363	11	5. 5	. 74	55. 21	31. 30	6. 6	5. 3	45. 4
RSL 63133	A3	8-16	2. 68	. 228	12	6. 8	. 75	49. 91	37. 87	7. 0	5. 8	60. 6
RSL 63134	B21	16-29	1. 51	. 120	13	5. 7	. 76	65. 13	41. 86	7. 6	6. 4	68. 1
RSL 65135	B22	29-45	. 83	. 067	12	5. 0	. 90	56. 97	35. 85	8. 1	6. 9	61. 3
RSL 65136	Cca	45-60	. 66	. 054	12	5. 1	. 97	55. 01	33. 31	8. 1	7. 2	57. 2
Waikaloa very fine sandy loam:												
S65Ha-1-2												
RSL 65175	Ap	0-5	7. 53	. 671	11	6. 6	. 71	44. 80	32. 63	6. 6	5. 7	55. 2
RSL 65176	A12	5-10	3. 69	. 324	11	7. 4	. 69	51. 37	38. 19	7. 1	6. 2	51. 6
RSL 65177	A3	10-20	1. 88	. 161	12	7. 9	. 71	62. 90	39. 13	7. 3	6. 2	51. 7
RSL 65178	B21	20-25	1. 02	. 110	9	7. 9	. 75	61. 38	39. 24	7. 5	6. 3	50. 2
RSL 65179	IIB22	25-31	. 77	. 086	9	7. 8	. 76	59. 71	37. 27	7. 6	6. 4	51. 7
RSL 65180	IIC1ca	31-39	. 31	------	------	7. 3	. 81	50. 50	32. 18	7. 8	6. 5	50. 0
RSL 65181	IIC2ca	39-50	. 15	------	------	3. 0	. 98	38. 48	23. 08	8. 1	6. 8	39. 9
RSL 65182	IIC3b	50-65+	. 11	------	------	2. 1	. 94	39. 46	24. 83	8. 2	6. 9	47. 7

[1] Determined by the Hawaiian Sugar Planters Association.
[2] Determined by the Hawaii Agricultural Experiment Station, University of Hawaii.

analysis of selected soils—Continued

Extractable bases (Meq./100 gm.)				Base saturation (NH_4OAc)	Total analysis [2]											
Ca	Mg	Na	K		SiO_2	TiO_2	Al_2O	Fe	MnO	MgO	CaO	Na_2O	K_2O	P_2O	LOI	$H_2O(-)$
				Pct.	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*
8. 6	8. 1	. 5	2. 8	100	26. 68	4. 58	25. 86	23. 68	. 38	1. 31	. 76	. 34	. 49	. 46	11. 30	4. 50
4. 4	5. 0	. 9	1. 4	75	24. 90	4. 75	28. 74	21. 89	. 34	. 88	. 18	. 19	. 50	. 32	12. 04	6. 38
4. 1	5. 4	3. 5	. 8	85	12. 26	9. 38	23. 72	32. 89	. 28	. 87	. 76	. 17	. 31	. 43	13. 58	5. 78
4. 6	6. 1	6. 2	1. 4	100	9. 46	11. 06	22. 47	34. 05	. 11	1. 06	2. 16	. 19	. 22	. 40	13. 32	5. 84
13. 7	13. 1	. 4	. 7	50	12. 73	2. 76	13. 09	14. 74	. 17	2. 46	. 94	. 14	. 25	. 83	35. 12	16. 26
9. 4	9. 1	. 2	. 3	31	10. 55	3. 73	13. 96	20. 89	. 19	1. 35	. 60	. 12	. 39	. 73	31. 13	16. 49
					10. 30	4. 79	13. 93	25. 34	. 16	. 94	. 27	. 06	. 45	. 16	27. 11	16. 89
1. 2	1. 8	. 2	. 1	9	9. 30	5. 13	17. 75	22. 56	. 16	. 52	. 00	. 05	. 43	. 71	25. 93	17. 41
1. 4	1. 3	. 2	. 2	9	8. 10	3. 25	19. 56	16. 50	. 10	. 46	. 00	(3)	. 11	. 71	29. 60	21. 72
. 4	2. 0	. 2	. 1	9	11. 29	2. 00	24. 58	10. 10	. 05	. 83	. 00	(3)	. 00	. 65	26. 66	23. 71
7. 0	3. 8	. 4	. 5	36	24. 32	6. 30	21. 61	25. 50	. 52	1. 04	. 04	. 10	. 92	. 69	14. 04	6. 08
7. 0	3. 6	. 6	. 1	33	23. 74	6. 14	21. 88	25. 64	. 54	. 98	. 04	. 18	. 92	. 72	13. 54	6. 14
4. 9	2. 3	1. 0	. 1	35	21. 34	6. 74	20. 98	29. 81	. 20	. 92	(3)	. 09	. 92	. 67	11. 34	7. 20
3. 3	1. 4	. 6	. 1	28	17. 06	9. 20	19. 30	34. 84	. 18	. 84	. 00	. 09	. 94	. 74	10. 90	6. 28
6. 5	3. 4	. 8	. 1	39	14. 00	7. 10	22. 39	32. 89	. 16	. 88	. 03	. 08	. 40	. 84	13. 88	7. 60
6. 4	3. 0	. 9	. 1	33	15. 80	5. 71	29. 12	23. 32	. 23	. 82	(3)	. 09	. 16	. 85	15. 40	8. 84
17. 2	9. 1	. 7	. 7	60	45. 58	2. 12	12. 36	11. 26	. 24	3. 83	1. 72	. 50	. 19	. 60	11. 18	10. 72
22. 8	11. 7	1. 0	. 7	72	37. 88	2. 57	13. 70	13. 76	. 22	5. 25	1. 83	. 44	. 19	. 55	9. 98	14. 14
33. 7	19. 2	1. 8	. 5	87	31. 02	2. 95	16. 51	15. 01	. 24	4. 05	1. 50	. 31	. 07	. 29	9. 74	18. 34
35. 8	23. 8	2. 1	. 3	97	28. 10	3. 13	17. 38	15. 82	. 23	3. 01	. 90	. 28	. 07	. 17	9. 94	21. 56
34. 4	26. 5	1. 9	. 2	93	30. 32	3. 05	17. 58	16. 63	. 22	3. 85	. 90	. 19	. 07	. 16	10. 06	17. 70
22. 6	14. 0	1. 0	7. 4	88	41. 10	1. 98	12. 31	10. 41	. 16	7. 78	2. 80	. 56	. 53	. 54	13. 54	8. 80
17. 9	12. 0	1. 6	4. 7	80	38. 60	2. 68	12. 87	10. 97	. 20	8. 28	2. 67	. 54	. 46	. 56	11. 38	11. 38
31. 1	18. 9	2. 9	4. 0	94	30. 34	2. 68	15. 04	13. 59	. 23	9. 57	2. 48	. 48	. 38	. 43	10. 52	15. 26
37. 5	23. 5	2. 9	4. 9	100+	32. 44	2. 74	17. 49	14. 07	. 19	5. 86	3. 32	. 58	. 39	. 26	8. 56	14. 40
36. 4	28. 7	6. 1	5. 2	100+	36. 28	2. 55	15. 26	13. 21	. 17	6. 53	4. 49	. 80	. 45	. 76	7. 12	13. 10
30. 8	28. 4	12. 0	6. 1	100+	37. 58	2. 30	14. 76	12. 51	. 18	7. 52	5. 92	. 97	. 50	. 23	8. 46	10. 00
27. 9	7. 8	. 4	4. 8	81	24. 54	3. 30	18. 60	12. 76	. 39	2. 91	3. 04	1. 55	. 71	. 56	16. 18	11. 72
28. 0	6. 4	. 4	5. 6	78	27. 32	2. 94	19. 86	12. 51	. 35	2. 38	2. 95	1. 86	. 72	. 51	12. 22	16. 86
32. 6	7. 1	. 8	4. 8	88	29. 98	2. 68	20. 53	12. 80	. 36	1. 69	2. 87	1. 88	. 73	. 37	9. 70	16. 78
34. 6	9. 8	1. 1	3. 0	97	32. 22	2. 80	20. 03	12. 63	. 39	1. 73	2. 87	1. 88	. 68	. 32	8. 30	16. 62
33. 3	12. 8	1. 6	. 6	93	34. 38	3. 73	19. 19	12. 59	. 37	1. 78	2. 70	2. 05	. 78	. 31	7. 78	14. 76
33. 0	15. 9	2. 2	. 3	100+	39. 44	2. 83	18. 39	12. 23	. 35	1. 83	1. 86	2. 13	1. 25	. 23	7. 56	11. 98
34. 0	12. 4	5. 4	. 5	100+	48. 18	2. 28	18. 87	6. 21	. 27	. 93	2. 42	3. 90	2. 51	. 08	7. 52	7. 24
33. 3	14. 4	6. 1	1. 3	100+	51. 90	1. 48	19. 65	4. 51	. 29	. 72	1. 56	3. 90	2. 48	. 08	7. 08	6. 92

[3] Trace.

Free iron oxide was determined by dithionite-citrate extraction and orthophenanthroline colorimetry (*1*), modified by shaking overnight instead of heating.

Bulk density was determined from core samples oven dried at 105° C. Two samples each were taken at 3-inch increments to a depth of 60 inches. The reported values are the means for the horizons.

Moisture retention was determined at ⅓ and 15 atmospheres using the Richards (*11*) pressure membrane apparatus.

The pH was determined by glass electrode, using soil-water and soil-potassium chloride ratios of 1:5, except 1:1 ratios were used for Pakini, Kawaihae, and Waikaloa soils (*10*).

Cation exchange capacity was determined by direct distillation of absorbed ammonia after saturation with ammonium acetate (*10*).

Extractable calcium, magnesium, sodium, and potassium were determined by extraction with neutral normal ammonium acetate (*10*). Calcium and magnesium were separated with alcohol and determined by EDTA titration (*4*). Sodium and potassium were determined on original extracts using flame photometry (*6*).

Total analysis was determined by standard methods used by the Hawaii Agricultural Experiment Station of the University of Hawaii.

General Nature of the Island

This section describes the geology, physiography, and climate of the island and gives general information about the transportation, population, recreational facilities, and farming.

Geology and Physiography

The Island of Hawaii is the largest and youngest island in the Hawaiian group. It was built from the ocean floor by voluminous outpourings of lava from five volcanoes—Kohala, Mauna Kea, Hualalai, Mauna Loa, and Kilauea. The volcanos are believed to have started in the Tertiary period (*16*).

The Kohala volcano on the northern end of the island, 5,505 feet high, became extinct in the Middle Pleistocene. This volcano was deeply eroded on the windward side near the end of the Pliocene time.

Mauna Kea, the highest mountain, reaches 13,784 feet above sea level. The volcano has not erupted during historic time. It is built up of olivine basalt and covered with layers of volcanic ash. These individual ash layers vary in thickness from less than an inch to about 4 or 5 feet. During the Wisconsin stage of glaciation in North America, Mauna Kea was capped by a small glacier.

Hualalai mountain, 8,251 feet high, is built up of basalts. A large trachyte pumice cone of Puuwaawaa occurs on the northern slope. The last eruption of Hualalai, in 1800–1801, produced olivine basalt.

Mauna Loa covers an area of 2,035 square miles or 50 percent of the island. It is 13,680 feet high and last erupted in 1950. Mauna Loa and Mauna Kea receive an annual blanket of snow that lasts for a couple of months during the winter.

The Kilauea volcano, 4,090 feet high, originated on the southern slopes of Mauna Loa. Its lavas are largely olivine basalt. The flows in recent years have not been of the explosive type, and it has been possible to observe them safely at reasonably close range. The most spectacular eruption occurred in 1959 when Kilauea Iki erupted and sent fountains of lava shooting 1,900 feet in the air. The following year, a flank eruption engulfed the town of Kapoho. Since then, many eruptions of short duration have occurred along the fissure zone.

The topography of the island reflects the volcanic activity. In the northern and eastern sections where volcanic flows have not occurred recently, the terrain has been eroded by rivers and streams. The stream pattern is more or less radial. The spaces between drainages are narrow. In the southern section the terrain is undissected, is quite barren, and reveals large areas of exposed lava.

The valleys draining the rainy, windward slopes of Mauna Kea are younger and therefore smaller than those of the Kohala Mountains. The dry western slope of Mauna Kea is largely undissected by stream erosion. The prominent gulches in the upper slopes of Mauna Kea have a distinct relationship to the glaciers which covered the top of the mountain during the late Pleistocene time. Shallow gulches drain the south-western slopes of Mauna Loa.

The Waimea plains were formed by the Mauna Kea lava ponding against the older Kohala Mountains. The plains are covered with volcanic ash. The Interior Plateau at Pohakuloa is covered with fresh lava from Mauna Loa banking against Mauna Kea and Hualalai.

Wave actions have eroded the basic rock and formed high sea cliffs that extend along the entire windward coast from Hilo northward to Kohala. These nearly vertical cliffs range from 50 to 350 feet in height. Along the leeward coast where there is less action, the cliffs are generally less than 50 feet in height.

Bays and sandy beaches are scarce along the rugged coastline. Hilo, Kailua, and Kawaihae are the largest bays. There are black sandy beaches at Kalapana, Kapoho, and Punaluu and a few scattered coral sand beaches on the western side of the island.

Climate [6]

The climate of the Island of Hawaii is unusually pleasant for the tropics. Its outstanding features are the remarkable differences in rainfall over short distances, the mild temperatures, the persistence of the northeasterly trade winds, and the development of distinct climatic regimes in localities sheltered from the prevailing wind. Tables 7 and 8 show data on temperature and rainfall.

The major climatic controls in this region are exercised (1) by latitude—the island lies well within the geographic tropics; (2) by the surrounding ocean with

[6] By SAUL PRICE, regional climatologist, National Weather Service, U.S. Department of Commerce.

its moderating influence on temperature; and (3) by the Pacific anticycline from which the trade winds flow. Between October and April, storms moving eastward across the Pacific north of Hawaii or forming nearby (the so-called Kona storms) occasionally bring in spells of bad weather and widespread heavy rain. But this island, because of its more southerly latitude, experiences fewer of these than do the more northerly members of the group. Less often and mainly in summer, tropical storms originating off Mexico and drifting westward south of Hawaii may come close enough to bring a day or two of heavier rain.

TABLE 7.—*Precipitation data from selected stations*

[Dashes indicate no monthly totals recorded in this amount. Period of record for selected stations: Haina 214, 79 years; Hilo WBO 87.1, 26 years; Holualoa Beach 68, 48 years; Kainaliu 73.2, 38 years; Kohala 179.1, 73 years; Piihonua 89, 43 years; Puako 95.1, 31 years. Mean annual rainfall for selected stations: Haina 214, 64.06 inches; Hilo WBO 87.1, 136.62 inches; Holualoa Beach 68, 28.84 inches; Kainaliu 73.2, 71.26 inches; Kohala 179.1, 56.63 inches; Piihonua 89, 250.47 inches; Puako 95.1, 9.51 inches]

Month	Frequency percentage of monthly total rainfall in given amounts								Mean monthly rainfall
	0.50 inch or less	0.51–1 inch	1.01–3 inches	3.01–5 inches	5.01–10 inches	10.01–20 inches	20.01–40 inches	40.01 inches or more	
	Pct.	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Inches*
HAINA 214									
January	7	0	33	23	20	17	0	0	5.06
February	0	7	23	17	33	17	3	0	6.92
March	0	0	7	17	50	23	0	3	8.56
April	0	0	10	20	43	27	0	0	7.67
May	0	3	27	30	33	7	0	0	4.92
June	23	7	57	7	3	3	0	0	1.92
July	0	0	47	27	27	0	0	0	3.46
August	3	7	30	30	20	10	0	0	4.64
September	10	0	73	10	7	0	0	0	2.29
October	10	3	27	20	23	17	0	0	5.25
November	3	0	23	13	47	13	0	0	5.67
December	0	3	10	27	27	23	10	0	7.70
HILO WBO 87.1									
January	3	3	13	7	30	17	27	0	11.82
February	0	3	3	10	27	37	20	0	12.94
March	0	0	10	7	30	27	20	7	14.70
April	0	0	0	20	23	47	10	0	11.92
May	0	0	7	10	40	43	0	0	9.33
June	0	0	3	20	67	10	0	0	6.79
July	0	0	0	13	37	50	0	0	9.82
August	0	0	0	3	50	37	10	0	11.45
September	0	0	3	23	50	17	7	0	8.50
October	0	0	10	3	47	33	7	0	10.80
November	0	0	0	10	13	67	10	0	13.37
December	0	0	7	13	13	50	10	7	15.18
HOLUALOA BEACH 68									
January	27	10	37	10	13	3	----------	----------	2.30
February	23	13	47	10	7	0	----------	----------	1.86
March	3	10	60	13	13	0	----------	----------	2.47
April	0	17	57	23	3	0	----------	----------	2.31
May	0	7	50	43	0	0	----------	----------	2.65
June	0	0	57	27	17	0	----------	----------	3.33
July	0	7	73	17	3	0	----------	----------	2.54
August	7	0	50	30	13	0	----------	----------	2.86
September	3	3	60	23	10	0	----------	----------	2.71
October	7	0	57	33	3	0	----------	----------	2.48
November	20	17	47	13	3	0	----------	----------	1.77
December	17	27	40	17	0	0	----------	----------	1.56

TABLE 7.—*Precipitation data from selected stations*—Continued

KAINALIU 73.2

Month	Frequency percentage of monthly total rainfall in given amounts								Mean monthly rainfall
	0.50 inch or less	0.51–1 inch	1.01–3 inches	3.01–5 inches	5.01–10 inches	10.01–20 inches	20.01–40 inches	40.01 inches or more	
	Pct.	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Inches*
January	17	10	27	17	23	7	---	---	3.96
February	7	10	37	30	17	0	---	---	3.39
March	0	0	17	30	50	3	---	---	5.28
April	0	0	17	30	47	7	---	---	5.66
May	0	0	0	10	77	13	---	---	7.70
June	0	0	0	20	53	27	---	---	7.95
July	0	0	3	3	70	23	---	---	8.55
August	0	0	7	7	70	17	---	---	7.69
September	0	0	0	17	73	10	---	---	7.60
October	0	0	10	27	53	10	---	---	6.20
November	0	3	33	30	27	7	---	---	4.27
December	3	10	47	27	13	0	---	---	3.01

KOHALA 179.1

Month	0.50 inch or less	0.51–1 inch	1.01–3 inches	3.01–5 inches	5.01–10 inches	10.01–20 inches	20.01–40 inches	40.01 inches or more	Mean monthly rainfall
January	3	7	17	23	47	3	---	---	4.77
February	0	3	47	20	23	7	---	---	4.48
March	0	3	17	23	47	10	---	---	5.82
April	0	0	17	30	40	13	---	---	5.79
May	0	3	30	33	33	0	---	---	4.24
June	0	0	53	23	23	0	---	---	3.39
July	0	3	10	50	37	0	---	---	4.55
August	0	0	27	37	27	10	---	---	5.09
September	0	3	57	27	13	0	---	---	2.97
October	0	3	43	23	23	7	---	---	4.53
November	0	7	20	33	37	3	---	---	4.55
December	0	0	7	37	43	13	---	---	6.45

PIIHONUA 89

Month	0.50 inch or less	0.51–1 inch	1.01–3 inches	3.01–5 inches	5.01–10 inches	10.01–20 inches	20.01–40 inches	40.01 inches or more	Mean monthly rainfall
January	0	3	7	3	23	23	27	13	19.64
February	0	3	3	3	13	37	27	13	20.26
March	0	0	3	3	17	23	27	27	26.35
April	0	0	0	0	7	50	33	10	23.71
May	0	0	0	3	13	37	43	3	21.19
June	0	0	0	0	30	57	13	0	14.42
July	0	0	0	0	10	43	47	0	19.85
August	0	0	0	0	10	37	33	20	24.66
September	0	0	0	10	3	63	23	0	16.29
October	0	0	0	3	7	62	24	3	17.74
November	0	0	0	0	13	27	57	3	22.86
December	0	0	7	7	7	33	33	13	23.50

PUAKO 95.1

Month	0.50 inch or less	0.51–1 inch	1.01–3 inches	3.01–5 inches	5.01–10 inches	10.01–20 inches	20.01–40 inches	40.01 inches or more	Mean monthly rainfall
January	43	11	21	18	4	4	---	---	1.83
February	50	14	32	0	4	0	---	---	.94
March	39	21	29	7	4	0	---	---	1.28
April	59	30	7	4	0	0	---	---	.57
May	68	11	21	0	0	0	---	---	.48
June	75	25	0	0	0	0	---	---	.24
July	74	19	7	0	0	0	---	---	.37
August	81	11	7	0	0	0	---	---	.30
September	59	22	19	0	0	0	---	---	.51
October	59	11	19	11	0	0	---	---	.74
November	54	7	32	4	4	0	---	---	1.02
December	39	11	39	11	0	0	---	---	1.23

TABLE 8.—*Mean minimum and maximum monthly temperatures at selected stations*

Station and number	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.
Haina 214												
Mean maximum	77.0	77.4	77.6	77.7	79.3	80.9	81.5	82.0	82.5	81.8	79.6	77.5
Mean minimum	61.8	61.6	62.1	63.2	64.6	65.9	66.9	67.6	67.0	66.4	64.7	63.1
Hilo WBO 87.1												
Mean maximum	78.7	78.6	78.2	78.9	80.4	82.0	82.4	83.1	82.9	82.5	80.4	78.8
Mean minimum	62.8	62.6	63.0	64.3	65.6	66.6	67.4	68.4	68.1	67.6	65.9	64.1
Holualoa Beach 68												
Mean maximum	80.8	80.7	81.1	81.7	82.2	82.6	83.8	84.7	84.8	84.6	83.1	81.3
Mean minimum	63.6	64.0	64.3	65.9	67.6	68.4	69.1	69.6	69.5	68.7	67.0	64.4
Kainaliu 73.2												
Mean maximum	77.1	77.7	77.6	77.7	77.3	77.7	79.5	80.4	80.9	80.7	79.5	77.9
Mean minimum	57.6	57.5	57.9	58.9	60.5	62.1	62.4	63.3	62.9	62.2	60.6	58.7
Kohala 179.1												
Mean maximum	77.5	77.2	77.5	77.5	79.2	80.2	80.7	81.4	82.0	81.6	79.7	78.1
Mean minimum	62.6	62.7	63.2	64.2	65.6	67.3	68.2	68.8	68.7	67.5	66.0	64.1
Piihonua 89												
Mean maximum	74.9	74.7	73.1	74.1	75.2	76.6	77.1	77.8	78.2	77.9	76.0	74.2
Mean minimum	56.0	55.8	56.3	58.1	59.0	60.0	61.2	62.1	61.1	60.2	59.3	57.4
Puako 95.1												
Mean maximum	82.8	82.9	84.0	85.1	86.9	88.1	88.8	89.2	89.2	88.1	86.4	84.2
Mean minimum	65.6	65.4	65.8	66.6	68.5	70.0	70.9	71.7	71.5	70.8	69.4	66.7

Superimposed upon these climatic controls is the topography, which creates a diversity of micro-climates on an island that would otherwise have a uniform climate. The elevations are the greatest in the State. They range from sea level along the coast to nearly 14,000 feet on Mauna Loa and Mauna Kea, the vast mountains whose slopes comprise most of the island's area. Other high points are the summit of Hualalai, 8,271 feet, and of the Kohala Mountains, 5,480 feet. Because much of Hawaii is covered by relatively recent lava flows, it is far less extensively dissected by deep gorges and ridges than the other islands of the State.

Rainfall.—Over the open sea around the Hawaiian Islands, rainfall averages between 25 and 30 inches a year. Yet the island itself receives more than 10 times this amount in some places and less than half in others. The principal cause of this extreme variability and of amounts that rival the greatest on earth is the rain that forms within the moist trade wind air as it ascends and traverses the topographic barriers.

On lower mountains, like the Kohalas, the mean distribution of these "orographic" (mountain-caused) rains resembles the contours of elevation. The amounts of rainfall are greatest over windward slopes and crests and least over leeward lowlands. But on the higher peaks, the average rainfall is greatest at only 2,000 to 4,000 feet and decreases with further elevation, reflecting the tendency of the air to flow around rather than over these loftier obstacles. Thus, parts of Mauna Kea's windward slopes receive more than 300 inches annually, while its summit and that of Mauna Loa and Hualalai receive less than 25 inches. In the entire State the driest place, which receives less than 10 inches annually, is the coast leeward of the Kohala Mountains and in the saddle between the Kohalas and Mauna Kea.

Thus, the island's large area and the height and extent of its great mountains have facilitated the development of a variety of local climates, the characteristics of which depend chiefly on the degree of exposure to the prevailing trade winds. The best known of these is the Kona district of which more will be said later.

As one consequence of this diversity, geographical differences in the seasonal variation of rainfall are much more complex than on the smaller islands. Although generalization is difficult, the normally dry areas have arid summers because they obtain their rainfall chiefly from a few winter storms and only negligibly from trade wind showers; but the wetter areas have much less seasonal difference because they derive their rainfall from winter storms and from the year-round trade wind showers. For example, Puako is one of the driest localities in the State and has a mean annual rainfall of less than 10 inches. June, July, and August together account for only 3 percent of the year's rain and January accounts for 18 percent. In contrast, Hilo receives about 140 inches annually. June, July, and August account for 15 percent of the year's rain, and March accounts for 12 percent.

Almost unique in the State is the Kona district's pronounced summer rainfall maximum, which is probably attributable to the greater intensity of the daytime onshore winds that ascend the leeward slopes of Mauna Loa and Hualalai and produce much of the area's cloud and rainfall. Thus, Kainaliu, which receives about 72 inches annually, receives about 12 percent of the annual rainfall in June and only 5 percent in January.

The number of rainy days also varies widely from place to place and is generally greater where the mean annual rainfall is higher. Of the three localities discussed, Puako receives 0.1 inch or more on an average of 13 days a year, and 0.5 inch or more on only 3 days—all of the latter in the winter months. In contrast Hilo had 208 days and 79 days, respectively, in those two categories and some days in each month. Kainaliu, whose annual rainfall is intermediate between Puako and Hilo, receives an average of 0.1 inch or more on 132 days and 0.5 inch or more on 43 days, the greater number of days being in May through September.

Some of Hawaii's heaviest rains come from towering cumulus clouds that build up over mountains and interiors on warm calm afternoons. Although these "convective" showers are sometimes intense enough to cause flash flooding, they are usually too brief and localized to contribute significantly to water needs.

The more widespread heavy rains are brought by winter storms. Although terrain does not affect these storms as much as it affects trade wind showers, large differences in rainfall do occur over small distances, owing to topography and to the path and structure of the rain clouds. Frequently, the most copious rain storms occur in dry areas, and during such storms these areas sometimes receive within a single day, or even a few hours, half or more of their mean annual rainfall.

Accumulations of 2 inches an hour are not uncommon, and 4 inches or more an hour occurred somewhere on the island in more years than not. The island's record 24-hour rain was 31.95 inches at Honomu Mauka on February 20, 1918. On the next day 11.84 inches of rain fell, and the two-day total was 43.79 inches. The 31.95 inches at Honomu Mauka is appreciably less than the approximately 40 inches registered in a single day by a recording gage at Kilauea Plantation, Kauai, in January 1956. The 31.95 inches at Honomu, however, is based on daily readings made at a fixed time, while that at Kilauea represents the accumulation during the 24 successive hours of heaviest rain. Of the Kilauea Plantation total, 6 inches fell in 30 minutes and more than 11 inches in a single hour.

Because of such intensities and despite high interception and infiltration rates, flash flooding is a recurrent problem and frequently damages fields, crops, roads, and other property.

Another important, but often overlooked, source of water is that intercepted directly from passing clouds by vegetation and soils whose elevation of about 2,500 feet or more brings them into the cloud belt. Although comparable measurements have not been made on the Island of Hawaii, at Lanai Hale, Lanai, the annual catch of this so-called "fog drip" appears to be about equal to the rainfall.

At the opposite extreme, drought is not uncommon although it rarely affects more than part of the island at one time. Drought may occur when the winter storms or the trade winds fail. If the winter storms fail, the areas that receive little trade wind rain are hardest hit; and a dry winter between two normally arid summers can have serious consequences. The failure of the trade winds most affects the windward slopes, including many sources of irrigation water. The probability of serious drought somewhere on the island during any given 10-year period exceeds 90 percent. Some areas like Kohala and Hamakua, although in the zone of 100-inch to 200-inch mean annual rainfall, are particularly vulnerable.

Temperature.—The mean annual temperature of the island varies between 72° and 75° F. near sea level. It decreases by about 3° for each 1,000 feet of elevation and tends to be higher in sunny, dry areas. The average annual temperature is 73° at Hilo, 67° at Mountain View (1,530 feet), 64° at Kamuela Airport (2,665 feet), 61° at Hawaii National Park (3,971 feet), and 45° at Mauna Loa Observatory (11,150 feet). The average difference between daily high and low temperature is 10° to 20°. The greater differences are at localities that are higher, drier, and less open to the wind. Thus, the mean daily range is 15° at Hilo, 18° at Kamuela Airport, and 20° at Mauna Loa Observatory. In the Kona district the mean daily range is 15° at Kona Airport, which is at sea level, and 18° at Kainaliu, which is 1,500 feet.

August and September are the warmest months; January, February, and March are the coolest. The seasonal range is only 4° to 8°, which is much below the daily range. Thus, temperature changes more in the course of an average day than from season to season. In addition, the average nighttime temperature during most of the year is below the mean temperature of the coolest months, thus confirming the old adage that "nighttime is the winter of the tropics."

Almost everywhere at low elevations the highest temperatures of the year are in the low 90's and the lowest near 50°. The warmest days are usually during "Kona weather" when the trade winds fail, skies are clear, and air stagnates over the heated island. The coldest days occur when polar air invades in the wake of a winter storm.

Wind.—The prevailing wind throughout the year is the east northeasterly trade wind. Consequently, in Hawaii the geographical term, "windward," has come to mean the trade wind rather than the existing wind. Nevertheless, the trade winds do vary greatly in frequency. They are sometimes virtually absent for long periods; at other times they blow for weeks on end. Generally, however, the trade winds are more persistent in summer than in winter. They range over the open sea near Hawaii from a minimum of about 50 percent of the time in January to a maximum of more than 90 percent in July and an annual frequency of about 70 percent.

In well-exposed areas the trade winds average about 15 miles an hour and are slightly stronger in summer than winter. Trade winds exceed a speed of 31 miles an hour only about 2 percent of the time. Winds from other directions exceed this speed about 3 percent of the time.

The strongest and most damaging winds are not ordinarily the trade winds, except in places affected by local terrain. The strongest winds are those that accompany winter storms, severe thunderstorms, and infrequent hurricanes. High winds are most likely between November and March and may come from almost any direction. The strongest wind of recent years was a gust of 103 miles an hour at Kilauea Point, Kauai, in August 1959 during Hurricane Dot. Gusts exceeding 80 miles an hour have occasionally occurred elsewhere.

The effect of local topography on wind is varied and extreme, ranging from complete sheltering to acceleration through passes and narrow valleys, which can transform a moderate wind into a strong, gusty one. Thus, in the channels between the islands at Upolu Point and South Point and in the Kamuela-Waimea area in the saddle between Mauna Kea and the Kohala Mountains, the trade winds are much stronger than over the open sea.

Hilo, on the other hand, although well exposed to the northeasterly trade winds, ordinarily experiences these winds only during the day. At night they are replaced by a southwesterly breeze that drifts downslope off Mauna Loa and is the prevailing wind. In even greater contrast, the Kona area on the western side of the island is so completely sheltered by the high mountains to the east that the trade winds are never felt; and the prevailing winds are onshore sea breezes during the day and offshore land breezes at night.

Cloud cover.—On trade wind days, the Kohala Mountains, like the other relatively low mountains of the State, are capped by cumulus clouds that overhang the slopes and coastal plains. Like the orographic rainfall with which they are associated, these clouds form within the moist marine air ascending the slopes and dissipate as the air sinks to the leeward side. Hence clouds are more frequent and extensive over windward coasts and mountains than over leeward plains and shores. Against the windward slopes of Mauna Loa and Mauna Kea, at elevations between 2,000 and 7,000 feet, the trade wind clouds form a collar through which the upper slopes of the great mountains project. Similar cloud belts form at about the same elevation on the Kona slopes of these mountains and of Hualalai, produced there not by the trade winds but by the daytime ascent of moist onshore breezes.

At Hilo Airport, which is a wet, windward station, skies are clear (sky cover three-tenths or less) 8 percent of the time and cloudy (sky cover eight-tenths or more) 58 percent. By contrast, at Honolulu Airport, which is a relatively dry station (22 inches annually) on Oahu, the corresponding percentages are 26 and 28.

Seasonal and diurnal variations in cloudiness also exist. In most areas and months, probably due to solar heating, clouds tend to be more abundant during the day than at night. This is particularly noticeable in Kona, where clouds form during the day in the onshore sea breezes as they glide up mountain and dissipate by evening when the flow reverses and moves out to sea.

Widespread cloudiness is characteristic of the lower windward and leeward slopes during trade wind weather, but persistent cloudiness is principally characteristic of the large winter storms. Even the heaviest overcast, however, seldom lasts for more than a day or two without at least a few moments of blue sky and sunshine.

Relative humidity.—Relative humidity varies considerably with time and place. In general, it is higher at night than in the afternoon, and higher in wetter, cooler localities than in drier, warmer ones. Since the trade winds reach the island from cooler latitudes, the humidity is by no means as high as would be expected of the tropical locale and surrounding ocean. At Hilo the average humidity is about 80 percent in both January and July but ranges from about 87 percent at 2 a.m. to 68 percent at 2 p.m. By comparison, the average humidity at Honolulu Airport is 70 percent in January and 68 percent in July, and ranges from 74 percent at 2 a.m. to 58 percent at 2 p.m.

Severe weather.—Hurricanes, so destructive to property and crops in the continental United States, are relatively infrequent and mild in Hawaii.

The years prior to 1950 contain no authenticated reports of hurricanes in the Hawaiian area, but four have occurred since then and a number of others have approached the State although not closely enough to affect the weather appreciably. The most damaging hurricane, Dot in August 1959, did approximately $6 million in damage, mostly on Kauai, and about $1.5 million of it to sugarcane. Kanoa, another of the four hurricanes, moved directly toward the island from the east but weakened abruptly as it reached the eastern coast.

Tornadoes.—Although 20 or so funnel clouds are reported over or near the State during an average year, most of these fail to reach the surface or they remain at sea as waterspouts. Only occasionally a small tornado does some slight damage. A number of funnels have been sighted over the island during recent years, and others may have been responsible for local wind damage of undetermined origin. The most destructive tornado on record apparently was the one that swept through the small plantation town of Kaumakani, Kauai, early on December 17, 1967 and left behind $300,000 in damage to houses and crops.

Hail.—On the average, hail falls several times a year somewhere in the State but is almost invariably small—a quarter inch or less in diameter—and so does little damage. At times, however, leafy crops have been severely battered. Although hail occurs most frequently between October and April, it has been reported in every month but July. It usually covers only a square mile or less but occasionally is much more widespread.

Transportation

The Island of Hawaii has two deep-water harbors—Hilo Harbor and Kawaihae Harbor. These two facilities serve both ends of the island for exports of sugar, cattle, and other commodities and for imports of capital and consumer goods. Most fuel, equipment, supplies, and construction material are imported. Scheduled barge transportation handles most of the interisland freight.

The General Lyman Field in Hilo accommodates the two scheduled interisland airlines that provide several daily scheduled flights. This airport also handles commercial jet flights that provide direct service between Hilo and the mainland cities. Other airport facilities serving the island are Kona and Kamuela.

Highways and roads circle the island. There are 1,311 miles of highways, including Federal, State, and county roads.

Population

The Island of Hawaii has a population of 65,941, which is about 8 percent of the civilian population of the State. The population of the island reached a peak

of 73,325 persons during 1930 and declined to a low of 60,000 in 1964 (*13*). This out-migration was caused by the mechanization and automation of the sugar industry, but the trend has been reversed by the visitor industry, which has boomed as a result of direct jet flights from the mainland.

About 42 percent of the population is concentrated in the Hilo area, the county seat and center of commerce and transportation. The rest of the population is distributed among many small plantation villages and towns scattered around the coastal fringes of the island.

Recreational Facilities

The Island of Hawaii has picturesque scenery and a pleasant climate for many outdoor activities. It offers such varied recreational opportunities as seeing an active volcano; observing volcanic formations, tropical vegetation, and wildlife; skiing on snow-capped Mauna Kea; sun bathing at Kawaihae; fishing for marlin at Kona; hunting wild pigs, goats, sheep, and small game on public hunting grounds; and golfing on any one of several courses.

The Hawaii Volcanoes National Park and the City of Refuge National Historical Park are of interest to many who visit the island.

Farming

The economy of the island has been based mainly on production of farm products. Sugarcane, beef cattle, and coffee are the three most important products in the order named. In 1966 the crop acreage of the island was 43 percent of the total for the State, the value of its crops marketed was 60 percent, and the value of its cattle and calves marketed was 56 percent. It produced all of the coffee and nearly all of the macadamia nuts grown in the State (*15*).

In recent years the production of macadamia nuts, papaya, and floral products has increased considerably and probably will continue to increase because of the direct air service from Hilo to the mainland.

Diversified crops.—The Island of Hawaii is the "bread basket" of the State. In addition to sugarcane, it produces vegetables, melons, papaya and other fruits, macadamia nuts, taro, and coffee. According to the 1967 Conservation Needs Inventory, the total acreage of these crops is about 18,540 acres. Coffee is grown on about 5,000 acres in Kona, the only coffee-producing area in the United States. About 95 percent of the crop is shipped to the mainland for blending. Papaya is grown mainly in the Kapoho area. Macadamia nuts are grown on about 4,500 acres in the Hamakua and Kau districts and in Hilo, Puna, and Kona (*15*). Vegetables are grown mainly in the Waimea, Kona, and Volcano districts (fig. 20). Most of the vegetables are shipped by barge to Honolulu.

Pineapples were grown in Kohala in the 1930's and again in the 1950's but were unprofitable.

Livestock.—The Island of Hawaii leads the State in production of cattle. In January 1967 there were 137,700 head of cattle on the island (*15*). The market value of the cattle production was a little more than half that of the State, and cattle accounted for two-thirds of the livestock receipts of the island. The beef cattle raised are Hereford, Angus, Shorthorn, and other breeds. They are shipped by barge to feedlots in Honolulu.

In 1967 there were 55 dairy farms and a total of 1,260 milk cows (*15*). The principal breeds of dairy cows are Holstein and Guernsey. Milk is marketed through local dairies.

Hogs are raised throughout the island on small farms. Most hogs are raised in concrete pens. A few are pastured in the Waimea and Kau areas. The principal breeds are Duroc-Jersey, Hampshire, Poland China, and Chester White.

In 1966 chickens and eggs accounted for 18 percent of the livestock receipts. The poultry industry has expanded steadily from small unit operations to substantial farms. The number of farms has decreased, but the flocks have increased. Most of the chickens are raised in wire-floored cages. In 1966, 138,000 hens produced 30.7 million eggs. In addition, 83,000 broilers were produced (*15*). Most of the eggs and chickens are marketed in Honolulu.

Sheep are raised for the local market at Humuula.

Floral products.—The export of floral products is steadily increasing. According to the U.S. Census of Agriculture for 1964, there were 216 anthurium farms on the island, and they sold 2,590,000 flowers. There were also 35 vanda-type orchid farms, which sold 27,817,600 flowers. Other floral products sold were woodroses, tropical foliage, lei flowers, and carnations and other cut flowers. Most of the anthuriums and orchids are grown in the Hilo, Pahoa, and Kapoho areas. Producing floral products is gradually emerging from a part-time enterprise to one requiring substantial capital and labor.

Visitor Industry

The visitor industry is the second largest source of income to the island and is expected to become the largest in a few years.

Direct air service from the mainland has increased the number of visitors to the Big Island. The active volcanoes, the tropical scenery, the pleasant climate, and the opportunities for hunting, fishing, and other outdoor sports offer visitors a number of recreational activities.

To accommodate visitors, several hotels are planned or are being built in the area between Kona and Kohala.

Literature Cited

(1) Aguilera, N. H., and Jackson, M. L.
1953. Iron oxide removal from soils and clays. Soil Sci. Soc. Am. Proc. 17: 359–364.

(2) American Association of State Highway Officials.
1961. Standard specifications for highway materials and methods of sampling and testing. Ed. 8, 2 v., illus.

(3) Association of Official Agricultural Chemists.
1955. Official methods of analysis. Ed. 8, pp. 805–806, illus.

(4) Barrows, H. L., and Simpson, E. C.
1962. An EDTA method for the direct routine determination of calcium and magnesium in soils and plant tissue. Soil Sci. Am. Proc. 26: 443–445.

Figure 20.—Landscape of the Waimea plains, where much of the vegetable crop of the State is grown. Windbreaks surround the farms, protect the crops, and help to control soil blowing.

(5) CLINE, M. G., and others.
1955. SOIL SURVEY OF THE TERRITORY OF HAWAII. U.S. Dept. Agr., 664 pp., illus.

(6) FIELDES, M., and others.
1951. ESTIMATION OF EXCHANGEABLE CATIONS IN SOILS WITH THE BECKMAN FLAME SPECTROPHOTOMETER. Soil Sci. 72: 219–232.

(7) GIESE, LAURENCE D.
1966. SOIL SURVEY AND LAND USE PLANNING WITH THE TROPICAL SOILS OF HAWAII. 8 pp.

(8) HAMILTON, R. A., and FUKUNAGA, E. T.
1959. GROWING MACADAMIA NUTS IN HAWAII. University of Hawaii, Hawaii Agr. Expt. Sta. Bul. 121.

(9) NELSON, ROBERT E., and WHEELER, PHILIP R.
1963. FOREST RESOURCES OF HAWAII—1961. Forestry Division, Dept. of Land and Natural Resources, State of Hawaii, and Forest Service, USDA. 48 pp., illus.

(10) PEECH, M., ALEXANDER, L. T., and others.
1947. METHODS OF SOIL ANALYSIS FOR SOIL-FERTILITY INVESTIGATIONS. U.S. Dept. Agr. Cir. 757, 25 pp.

(11) RICHARDS, L. A.
1947. PRESSURE-MEMBRANE APPARATUS CONSTRUCTION AND USE. Agr. Eng. 28: 451–454.

(12) SIMONSON, ROY W.
1962. SOIL CLASSIFICATION IN THE UNITED STATES. Sci. 137: 1027–1034, illus.

(13) STATE OF HAWAII, DEPARTMENT OF ECONOMIC DEVELOPMENT.
1961. FACT BOOK—COUNTY OF HAWAII. 64 pp.

(14) STATE OF HAWAII, DIVISION OF FISH AND GAME.
HUNTING IN HAWAII. 7 pp.

(15) STATE OF HAWAII, U.S. DEPARTMENT OF AGRICULTURE, HAWAII CROP AND LIVESTOCK REPORTING SERVICE.
1966. STATISTICS OF HAWAIIAN AGRICULTURE. 63 pp.

(16) STEARNS, H. T., and MACDONALD, G. A.
1946. GEOLOGY AND GROUND-WATER RESOURCES OF THE ISLAND OF HAWAII. Territory of Hawaii, Div. of Hydrology. Bul. 9.

(17) THORP, JAMES, and SMITH, GUY D.
1949. HIGHER CATEGORIES OF SOIL CLASSIFICATION: ORDER, SUBORDER, AND GREAT SOIL GROUPS. Soil Sci. 67: 117–126.

(18) UNITED STATES DEPARTMENT OF AGRICULTURE.
1938. SOILS AND MEN. U.S. Dept. Agr. Ybk., 1323 pp., illus.

(19) ———
1951. SOIL SURVEY MANUAL. U.S. Dept. Agr. Handbook No. 18, 503 pp., illus. [Supplement issued in May 1962.]

(20) ———
1960. SOIL CLASSIFICATION, A COMPREHENSIVE SYSTEM, 7TH APPROXIMATION. 265 pp., illus. [Supplements issued in March 1967 and September 1968.]

(21) ———
1961. LAND CAPABILITY CLASSIFICATION. U.S. Dept. Agr. Handbook No. 210, 21 pp.

(22) U.S. Department of Defense.
1968. Unified soil classification system for roads, airfields, embankments and foundations. MIL–STD–619S, 30 pp., illus.

(23) Walker, Ronald L.
Ancient and recent animal life. Hawaii Div. of Fish and Game, 2 pp.

Glossary

Aggregate, soil. Many fine particles held in a single mass or cluster. Natural soil aggregates such as crumbs, blocks, or prisms, are called peds. Clods are aggregates produced by tillage or logging. See structure.

Available water capacity (also termed available moisture capacity). The capacity of soils to hold water available for use by most plants. It is commonly defined as the difference between the amount of soil water at field capacity and the amount at wilting point. It is commonly expressed as inches of water per inch of soil.

Base saturation. The degree to which material that has base-exchange properties is saturated with exchangeable cations other than hydrogen, expressed as a percentage of the cation-exchange capacity.

Bulk density. The mass of dry soil per unit of bulk volume. Bulk volume is determined before drying to constant weight at 105 degrees centigrade. A unit of measure, usually grams per cubic centimeter or pounds per square foot.

Cation exchange capacity. The sum total of exchangeable cations that a soil can adsorb, expressed in milliequivalents per 100 grams of soil or of other adsorbing material, such as clay.

Clay. As a soil separate, the mineral soil particles less than 0.002 millimeter in diameter. As a soil textural class, soil material that is 40 percent or more clay, less than 45 percent sand, and less than 40 percent silt.

Consistence, soil. The feel of the soil and the ease with which a lump can be crushed by the fingers. Terms commonly used to describe consistence are—

Loose.—Noncoherent when dry or moist; does not hold together in a mass.

Friable.—When moist, crushed easily under gentle pressure between thumb and forefinger and can be pressed together into a lump.

Firm.—When moist, crushed under moderate pressure between thumb and forefinger, but resistance is distinctly noticeable.

Plastic.—When wet, readily deformed by moderate pressure but can be pressed into a lump; will form a "wire" when rolled between thumb and forefinger.

Sticky.—When wet, adheres to other material, and tends to stretch somewhat and pull apart, rather than to pull free from other material.

Hard.—When dry, moderately resistant to pressure; can be broken with difficulty between thumb and forefinger.

Weakly smeary.—When strong pressure is applied, soil material exhibits only weak thixotropic properties as evidenced by changing suddenly to fluid; the fingers "skid," and the soil smears. After the soil smears there is little or no evidence of free water on the fingers.

Moderately smeary.—Under moderate to strong pressure, soil material changes suddenly to fluid; the fingers "skid," and the soil smears and is slippery. After the soil smears, there is evidence of free water on the fingers.

Strongly smeary.—Under moderate pressure the soil material changes suddenly to fluid; the fingers "skid," and the soil smears and is very slippery. After the soil smears, free water is easily seen on the fingers.

Drainage, surface. Runoff, or surface flow, of water from an area.

Erosion. The wearing away of the land surface by wind (soil blowing), running water, and other geological agents.

Flood plain. Nearly level land, consisting of stream sediments, that borders a stream and is subject to flooding unless protected artificially.

Horizon, soil. A layer of soil, approximately parallel to the surface, that has distinct characteristics produced by soil-forming processes. These are the major horizons:

O horizon.—The layer of organic matter on the surface of a mineral soil. This layer consists of decaying plant residue.

A horizon.—The mineral horizon at the surface or just below an O horizon. This horizon is the one in which living organisms are most active and therefore is marked by the accumulation of humus. The horizon may have lost one or more of soluble salts, clay, and sesquioxides (iron and aluminum oxides).

B horizon.—The mineral horizon below an A horizon. The B horizon is in part a layer of change from the overlying A to the underlying C horizon. The B horizon also has distinctive characteristics caused (1) by accumulation of clay, sesquioxides, humus, or some combination of these; (2) by prismatic or blocky structure; (3) by redder or stronger colors than the A horizon; or (4) by some combination of these. Combined A and B horizons are usually called the solum, or true soil. If a soil lacks a B horizon, the A horizon alone is the solum.

C horizon.—The weathered rock material immediately beneath the solum. In most soils this material is presumed to be like that from which the overlying horizons formed. If the material is known to be different from that in the solum, a Roman numeral precedes the letter C.

R horizon.—Consolidated rock beneath the soil. The rock usually underlies a C horizon but may be immediately beneath an A or B horizon.

Igneous rock. Rock that has been formed by the cooling of molten mineral material. Examples: Granite, syenite, diorite, and gabbro.

Mottles. Irregular markings of different colors that vary in number and size. Mottling in soils usually indicates poor aeration and drainage. Descriptive terms are: Abundance—few, common, and many; size—fine, medium, and coarse; and contrast—faint, distinct, and prominent.

Parent material. The disintegrated and partly weathered rock from which soil has formed.

Permeability. The quality of a soil horizon that enables water or air to move through it. Terms used to describe permeability are as follows: *very slow, slow, moderately slow, moderate, moderately rapid, rapid,* and *very rapid.*

Plinthite. The sesquioxide-rich, humus-poor, highly weathered mixture of clay with quartz and other dilutants that commonly shows as red mottles, usually in platy, polygonal, or reticulate patterns. Plinthite changes irreversibly to hardpan or to irregular aggregates on repeated wetting and drying or it is the hardened relicts of the soft, red mottles. It is a form of the material that has been called laterite.

Profile, soil. A vertical section of the soil through all its horizons and extending into the parent material.

Reaction, soil. The degree of acidity or alkalinity of a soil, expressed in pH values. A soil that tests to pH 7.0 is precisely neutral in reaction because it is neither acid nor alkaline. The degrees of acidity or alkalinity are expressed thus:

	pH		*pH*
Extremely acid	Below 4.5	Mildly alkaline	7.4 to 7.8
Very strongly acid	4.5 to 5.0	Moderately alkaline	7.9 to 8.4
Strongly acid	5.1 to 5.5	Strongly alkaline	8.5 to 9.0
Medium acid	5.6 to 6.0	Very strongly alkaline	9.1 and higher
Slightly acid	6.1 to 6.5		
Neutral	6.6 to 7.3		

Residual material. Unconsolidated, partly weathered mineral material that accumulates over disintegrating solid rock. Residual material is not soil but is frequently the material in which a soil has formed.

Runoff (hydraulics). The part of the precipitation upon a drainage area that is discharged from the area in stream channels. The water that flows off the land surface without sinking in is called surface runoff; that which enters the ground before reaching surface streams is called ground-water runoff or seepage flow from ground water.

Sand. Individual rock or mineral fragments in soils having diameters ranging from 0.05 to 2.0 millimeters. Most sand grains consist of quartz, but they may be of any mineral composition. The textural class name of any soil that contains 85 percent or more sand and not more than 10 percent clay.

Silt. Individual mineral particles in a soil that range in diameter from the upper limit of clay (0.002 millimeter) to the lower limit of very fine sand (0.05 millimeter). Soil of the silt textural class is 80 percent or more silt and less than 12 percent clay.

Soil. A natural, three-dimensional body on the earth's surface that supports plants and that has properties resulting from the integrated effect of climate and living matter acting on parent material, as conditioned by relief over periods of time.

Solum. The upper part of a soil profile, above the parent material, in which the processes of soil formation are active. The solum in mature soil includes the A and B horizons. Generally, the characteristics of the material in these horizons are unlike those of the underlying material. The living roots and other plant and animal life characteristic of the soil are largely confined to the solum.

Structure, soil. The arrangement of primary soil particles into compound particles of clusters that are separated from adjoining aggregates and have properties unlike those of an equal mass of unaggregated primary soil particles. The principal forms of soil structure are—*platy* (laminated), *prismatic* (vertical axis of aggregates longer than horizontal), *columnar* (prisms with rounded tops), *blocky* (angular or subangular), and *granular*. *Structureless* soils are (1) *single grain* (each grain by itself, as in dune sand) or (2) *massive* (the particles adhering together without any regular cleavage, as in many claypans and hardpans).

Subsoil. Technically, the B horizon; roughly, the part of the solum below plow depth.

Substratum. Technically, the part of the soil below the solum.

Surface soil. The soil ordinarily moved in tillage, or its equivalent in uncultivated soil, about 5 to 8 inches in thickness. The plowed layer.

Terrace (geological). An old alluvial plain, ordinarily flat or undulating, bordering a river, lake, or the sea. Stream terraces are frequently called second bottoms, as contrasted to flood plains, and are seldom subject to overflow. Marine terraces were deposited by the sea and are generally wide.

Texture, soil. The relative proportions of sand, silt, and clay particles in a mass of soil. The basic textural classes, in order of increasing proportion of fine particles, are *sand, loamy sand, sandy loam, loam, silt loam, silt, sandy clay loam, clay loam, silty clay loam, sandy clay, silty clay,* and *clay*. The sand, loamy sand, and sandy loam classes may be further divided by specifying "coarse," "fine," or "very fine."

Water table. The highest part of the soil or underlying rock material that is wholly saturated with water. In some places, an upper, or perched, water table may be separated from a lower one by a dry zone.

GUIDE TO MAPPING UNITS

For a full description of a mapping unit, read both the description of the mapping unit and that of the soil series to which the mapping unit belongs. For information on capability classes and subclasses, refer to the section "Capability Grouping," page 54. In referring to a sugarcane group, pasture group, or woodland group, read the introduction to the section it is in for general information about its management. Other information is given in tables as follows:

Acreage and extent, table 1, page 9.

Engineering uses of soils, tables 2, 3, and 4, pages 74 through 100.

HIGH-INTENSITY SURVEY

Map symbol	Mapping unit	Described on page	Capability class or subclass		Sugarcane group		Pasture group		Woodland group	
			Irrigated	Nonirrigated	Number	Page	Number	Page	Number	Page
AaC	Ainakea silty clay loam, 3 to 12 percent slopes	8	---	IIIe	3	56	7	65	5	69
AaD	Ainakea silty clay loam, 12 to 20 percent slopes	10	---	IVe	3	56	7	65	5	69
AaE	Ainakea silty clay loam, 20 to 35 percent slopes	11	---	VIe	3	56	7	65	5	69
AkC	Akaka silty clay loam, 0 to 10 percent slopes	11	---	IIIe	4	57	8	65	6	70
AkD	Akaka silty clay loam, 10 to 20 percent slopes	11	---	IVe	4	57	8	65	6	70
AlC	Alapai silty clay loam, 0 to 10 percent slopes	12	---	IIIe	4	57	9	65	7	70
AlD	Alapai silty clay loam, 10 to 20 percent slopes	12	---	IVe	4	57	9	65	7	70
AlE	Alapai silty clay loam, 20 to 35 percent slopes	12	---	VIe	4	57	9	65	7	70
ApD	Alapai extremely stony silty clay loam, 10 to 20 percent slopes	13	---	VIIs	--	--	9	65	7	70
HaA	Hawi silty clay, 0 to 3 percent slopes	16	I	IIc	1	55	3	64	--	--
HaC	Hawi silty clay, 3 to 12 percent slopes	16	IIIe	IIIe	1	55	3	64	--	--
HeC	Hawi extremely stony silty clay, 6 to 12 percent slopes	16	---	VIIs	--	--	3	64	--	--
HlC	Hilea silty clay loam, 6 to 12 percent slopes	17	---	IVs	4	57	9	65	12	70
HoC	Hilo silty clay loam, 0 to 10 percent slopes	17	---	IIIe	2	56	9	65	7	70
HoD	Hilo silty clay loam, 10 to 20 percent slopes	18	---	IVe	2	56	9	65	7	70
HoE	Hilo silty clay loam, 20 to 35 percent slopes	18	---	VIe	2	56	9	65	7	70
HsC	Honokaa silty clay loam, low elevation, 0 to 10 percent slopes	19	---	IIIe	4	57	9	65	7	70
HsD	Honokaa silty clay loam, low elevation, 10 to 20 percent slopes	19	---	IVe	4	57	9	65	7	70
HsE	Honokaa silty clay loam, low elevation, 20 to 35 percent slopes	19	---	VIe	4	57	9	65	7	70
KaC	Kaiwiki silty clay loam, 0 to 10 percent slopes	23	---	IIIe	4	57	9	65	7	70
KaD	Kaiwiki silty clay loam, 10 to 20 percent slopes	23	---	IVe	4	57	9	65	7	70
KaE	Kaiwiki silty clay loam, 20 to 35 percent slopes	24	---	VIe	4	57	9	65	7	70
KfA	Kikoni very fine sandy loam, 0 to 3 percent slopes	30	I	IIc	--	--	12	66	9	70
KhA	Kohala silty clay, 0 to 3 percent slopes	31	I	IIc	1	55	5	64	4	69
KhC	Kohala silty clay, 3 to 12 percent slopes	32	IIIe	IIIe	1	55	5	64	4	69
KhD	Kohala silty clay, 12 to 20 percent slopes	32	IVe	IVe	1	55	5	64	4	69
KhE	Kohala silty clay, 20 to 35 percent slopes	32	VIe	VIe	1	55	5	64	4	69
KuC	Kukaiau silty clay loam, 6 to 12 percent slopes	32	---	IIIe	3	56	7	65	5	69
KuD	Kukaiau silty clay loam, 12 to 20 percent slopes	33	---	IVe	3	56	7	65	5	69
KuE	Kukaiau silty clay loam, 20 to 35 percent slopes	33	---	VIe	3	56	7	65	5	69
KwD	Kukaiau silty clay loam, moderately shallow, 12 to 20 percent slopes	33	---	IVe	3	56	7	65	5	69
MaA	Maile silt loam, 0 to 3 percent slopes	37	---	I	--	--	11	66	8	70
MoC	Moaula silty clay loam, 0 to 10 percent slopes	39	---	IIIe	3	56	7	65	5	69
MoD	Moaula silty clay loam, 10 to 20 percent slopes	40	---	IVe	3	56	7	65	5	69
MoE	Moaula silty clay loam, 20 to 35 percent slopes	40	---	VIe	3	56	7	65	5	69
NaC	Naalehu silty clay loam, 0 to 10 percent slopes	41	---	IIIe	2	56	5	64	2	68
NaD	Naalehu silty clay loam, 10 to 20 percent slopes	40	---	IVe	2	56	5	64	2	68
NaE	Naalehu silty clay loam, 20 to 35 percent slopes	41	---	VIe	2	56	5	64	2	68
NhD	Naalehu very rocky silty clay loam, 6 to 20 percent slopes	41	---	VIs	--	--	5	64	2	68
NlC	Niulii silty clay loam, 6 to 12 percent slopes	41	---	IIIe	3	56	7	65	5	69
NlD	Niulii silty clay loam, 12 to 20 percent slopes	41	---	IVe	3	56	7	65	5	69
NlE	Niulii silty clay loam, 20 to 35 percent slopes	41	---	VIe	3	56	7	65	5	69
OaC	Olaa silty clay loam, 0 to 10 percent slopes	42	---	IIIe	2	56	9	65	7	70
OlD	Olaa extremely stony silty clay loam, 0 to 20 percent slopes	42	---	VIIs	--	--	9	65	7	70
OoC	Ookala silty clay loam, 6 to 12 percent slopes	43	---	IIIe	2	56	7	65	5	69
OoD	Ookala silty clay loam, 12 to 20 percent slopes	43	---	IVe	2	56	7	65	5	69
OoE	Ookala silty clay loam, 20 to 35 percent slopes	43	---	VIe	2	56	7	65	5	69
PaC	Paauhau silty clay loam, 6 to 12 percent slopes	44	IIIe	IIIe	1	55	7	65	5	69
PaD	Paauhau silty clay loam, 12 to 20 percent slopes	44	IVe	IVe	1	55	7	65	5	69
PaE	Paauhau silty clay loam, 20 to 35 percent slopes	44	VIe	VIe	1	55	7	65	5	69
PeC	Panaewa very rocky silty clay loam, 0 to 10 percent slopes	45	---	VIs	2	56	9	65	12	70
Tr	Tropaquepts	51	IVw	IVw	--	--	6	64	3	69

424-785 O - 73 (Face cover 3) No. 1

GUIDE TO MAPPING UNITS--Continued

LOW-INTENSITY SURVEY

Map symbol	Mapping unit	Described on page	Capability class or subclass: Irrigated	Capability class or subclass: Nonirrigated	Sugarcane group: Number	Sugarcane group: Page	Pasture group: Number	Pasture group: Page	Woodland group: Number	Woodland group: Page
AFD	Apakuie very fine sandy loam, 12 to 20 percent slopes	13	---	VIe	--	--	14	67	16	71
ASD	Apakuie very stony very fine sandy loam, 12 to 20 percent slopes	14	---	VIs	--	--	14	67	16	71
BH	Beaches	14	---	VIIIw	--	--	--	--	--	--
FL	Fill land	14	IIe	IVs	--	--	2	64	--	--
HCD	Hanipoe very stony loam, 12 to 20 percent slopes	15	---	VIs	--	--	13	67	10	70
HDD	Hanipoe silt loam, 12 to 20 percent slopes	14	---	IVe	--	--	13	67	10	70
HFD	Hanipoe very rocky silt loam, 6 to 20 percent slopes	15	---	VIs	--	--	13	67	10	70
HHC	Heake very rocky sandy loam, 6 to 12 percent slopes	16	---	VIs	--	--	10	65	11	70
HKC	Heake extremely rocky sandy loam, 0 to 10 percent slopes	17	---	VIIs	--	--	10	65	11	70
HND	Honaunau silt loam, 6 to 20 percent slopes	18	---	IVe	--	--	9	65	7	70
HRD	Honaunau extremely rocky silty clay loam, 6 to 20 percent slopes	18	---	VIIs	--	--	9	65	--	--
HTD	Honokaa silty clay loam, 10 to 20 percent slopes	18	---	IVe	--	--	9	65	7	70
HTE	Honokaa silty clay loam, 20 to 35 percent slopes	19	---	VIe	--	--	9	65	7	70
HUD	Honuaulu very stony silty clay loam, 6 to 20 percent slopes	19	---	VIs	--	--	7	65	5	69
HVD	Honuaulu extremely stony silty clay loam, 12 to 20 percent slopes	20	---	VIIs	--	--	7	65	5	69
KBC	Kaalualu extremely stony loamy sand, 2 to 12 percent slopes	21	---	VIIs	--	--	2	64	--	--
KCD	Kahua silty clay loam, 6 to 20 percent slopes	22	---	VIw	--	--	8	65	6	70
KDD	Kainaliu very stony silty clay loam, 12 to 20 percent slopes	23	---	VIs	--	--	5	64	2	68
KEC	Kainaliu extremely stony silty clay loam, 12 to 20 percent slopes	22	---	VIIs	--	--	5	64	2	68
KGC	Kamakoa very fine sandy loam, 0 to 10 percent slopes	24	---	IIIe	--	--	4	64	1	68
KIC	Kamaoa loam, 6 to 12 percent slopes	24	---	IIIe	--	--	4	64	1	68
KJC	Kamaoa loam, moderately shallow, 6 to 12 percent slopes	25	---	IIIs	--	--	4	64	1	68
KKC	Kamaoa extremely stony loam, 6 to 12 percent slopes	25	---	VIIs	--	--	4	64	1	68
KLC	Kapapala loam, 0 to 10 percent slopes	26	---	IIIe	--	--	13	67	10	70
KLD	Kapapala loam, 10 to 20 percent slopes	25	---	IVe	--	--	13	67	10	70
KMD	Kapapala very rocky loam, 6 to 20 percent slopes	26	---	VIs	--	--	13	67	10	70
KNC	Kawaihae extremely stony very fine sandy loam, 6 to 12 percent slopes	26	---	VIIs	--	--	1	63	--	--
KOC	Kawaihae very rocky very fine sandy loam, 6 to 12 percent slopes	26	---	VIs	--	--	1	63	--	--
KPD	Kealakekua silty clay loam, 12 to 20 percent slopes	27	---	IVe	--	--	9	65	7	70
KRD	Kealakekua very stony silty clay loam, 6 to 20 percent slopes	27	---	VIs	--	--	9	65	7	70
KSD	Kealakekua extremely stony silty clay loam, 12 to 20 percent slopes	27	---	VIIs	--	--	9	65	7	70
KTB	Keekee loamy sand, 0 to 6 percent slopes	28	---	VIe	--	--	14	67	16	71
KVC	Kehena silty clay loam, 6 to 12 percent slopes	29	---	IIIe	--	--	8	65	6	70
KXC	Kikoni very fine sandy loam, 3 to 12 percent slopes	29	IIIe	IIIe	--	--	12	66	9	70
KYC	Kikoni extremely stony very fine sandy loam, 6 to 12 percent slopes	30	---	VIIs	--	--	12	66	9	70
KZD	Kilohana loamy fine sand, 12 to 20 percent slopes	31	---	VIe	--	--	14	67	16	71
LAD	Laumaia silt loam, 6 to 20 percent slopes	33	---	IVe	--	--	13	67	10	70
LUC	Laumaia extremely stony silt loam, 6 to 12 percent slopes	34	---	VIIs	--	--	13	67	10	70
MHC	Mahukona silty clay loam, 3 to 12 percent slopes	35	IIIe	IIIe	1	55	2	64	--	--
MKC	Mahukona very stony silty clay loam, 6 to 12 percent slopes	34	---	VIs	--	--	2	64	--	--
MLD	Maile silt loam, 6 to 20 percent slopes	35	---	IVe	--	--	11	66	8	70
MMD	Manahaa silt loam, 6 to 20 percent slopes	37	---	IVe	--	--	11	66	8	70
MND	Manahaa extremely stony silt loam, 6 to 20 percent slopes	38	---	VIIs	--	--	11	66	8	70
MT	Mixed alluvial land	39	---	VIw	--	--	7	65	5	69
OHC	Ohia silty clay loam, 0 to 10 percent slopes	41	---	IIIe	4	57	9	65	7	70
OSD	Ohia extremely stony silty clay loam, 0 to 20 percent slopes	42	---	VIIs	--	--	9	65	7	70
PKB	Pakini very fine sandy loam, 2 to 6 percent slopes	44	---	VIe	--	--	2	64	--	--
PLC	Palapalai silt loam, 6 to 12 percent slopes	45	---	IIIe	--	--	12	66	9	70
PMC	Palapalai silty clay loam, 6 to 12 percent slopes	45	---	IIIe	--	--	12	66	9	70
PND	Piihonua silty clay loam, 6 to 20 percent slopes	46	---	IVe	--	--	8	65	6	70
POD	Piihonua extremely stony silty clay loam, 6 to 20 percent slopes	47	---	VIIs	--	--	8	65	6	70
PPC	Puaulu silt loam, 0 to 10 percent slopes	47	---	IIIe	--	--	8	65	6	70
PRD	Punohu silt loam, 12 to 20 percent slopes	49	---	IVe	--	--	11	66	8	70
PSC	Puukala extremely stony silt loam, 6 to 12 percent slopes	49	---	VIIs	--	--	10	65	11	70
PTC	Puukala very rocky silt loam, 6 to 12 percent slopes	50	---	VIs	--	--	10	65	11	70
PUC	Puu Oo silt loam, 6 to 12 percent slopes	50	---	IIIe	--	--	11	66	8	70
PVD	Puu Pa extremely stony very fine sandy loam, 6 to 20 percent slopes	50	---	VIIs	--	--	2	64	--	--
PVF3	Puu Pa extremely stony very fine sandy loam, 70 to 100 percent slopes, severely eroded	51	---	VIIIs	--	--	--	--	--	--

424-785 O - 73 (Face cover 3) No. 2

Map symbol	Mapping unit	Described on page	Capability class or subclass		Sugarcane group		Pasture group		Woodland group	
			Irrigated	Nonirrigated	Number	Page	Number	Page	Number	Page
PWD	Puu Pa silt loam, 12 to 20 percent slopes	51	---	IVe	--	--	2	64	--	--
RB	Rough broken land	51	---	VIIe	--	--	--	--	--	--
UMD	Umikoa silt loam, 12 to 20 percent slopes	51	---	IVe	--	--	12	66	9	70
USD	Umikoa extremely stony silt loam, 12 to 20 percent slopes	52	---	VIIs	--	--	12	66	9	70
WAC	Waiaha silt loam, 0 to 10 percent slopes	53	---	IIIe	--	--	3	64	15	71
WAD	Waiaha silt loam, 10 to 20 percent slopes	53	---	IVe	--	--	3	64	15	71
WHC	Waiaha extremely stony silt loam, 6 to 12 percent slopes	52	---	VIIs	--	--	3	64	--	--
WKD	Waiaha very rocky silt loam, 10 to 20 percent slopes	53	---	VIs	--	--	3	64	--	--
WLC	Waikaloa very fine sandy loam, 6 to 12 percent slopes	53	---	IIIe	--	--	4	64	1	68
WMC	Waimea very fine sandy loam, 6 to 12 percent slopes	54	IIIe	IIIe	--	--	4	64	1	68
WSD	Waimea extremely stony very fine sandy loam, 12 to 20 percent slopes	54	---	VIIs	--	--	4	64	1	68

RECONNAISSANCE SURVEY

Map symbol	Mapping unit	Described on page	Irrigated	Nonirrigated	Sugarcane Number	Sugarcane Page	Pasture Number	Pasture Page	Woodland Number	Woodland Page
rAK	Akaka soils	11	---	IVe	--	--	8	65	6	70
rAM	Amalu soils	13	---	VIIw	--	--	--	--	--	--
rAR	Amalu-Rough broken land association	13								
	Amalu soils	--	---	VIIw	--	--	--	--	--	--
	Rough broken land	--	---	VIIIe	--	--	--	--	--	--
rCL	Cinder land	14	---	VIIIs	--	--	--	--	--	--
rHID	Huikau loamy sand, 12 to 20 percent slopes	20	---	VIe	--	--	14	67	16	71
rHID2	Huikau loamy sand, 12 to 20 percent slopes, eroded	20	---	VIIe	--	--	14	67	16	71
rHLD	Huikau extremely stony loamy sand, 12 to 20 percent slopes	20	---	VIIs	--	--	14	67	16	71
rHP	Hydrandept-Tropofolist association	20								
	Hydrandepts	--	---	IVe	--	--	--	--	6	70
	Tropofolists	--	---	VIIs	--	--	--	--	--	--
rKAD	Kahaluu extremely rocky muck, 6 to 20 percent slopes	21	---	VIIs	--	--	10	65	--	--
rKED	Kaimu extremely stony peat, 6 to 20 percent slopes	22	---	VIIs	--	--	5	64	--	--
rKFD	Keaukaha extremely rocky muck, 6 to 20 percent slopes	27	---	VIIs	--	--	9	65	--	--
rKGD	Keei extremely rocky muck, 6 to 20 percent slopes	28	---	VIIs	--	--	9	65	--	--
rKHD	Kekake extremely rocky muck, 6 to 20 percent slopes	29	---	VIIs	--	--	12	66	--	--
rKUC	Kilauea extremely gravelly sand, 6 to 12 percent slopes	30	---	VIIIs	--	--	--	--	--	--
rKXD	Kiloa extremely stony muck, 6 to 20 percent slopes	31	---	VIIs	--	--	9	65	13	71
rKYD	Kona extremely rocky muck, 6 to 20 percent slopes	32	---	VIIs	--	--	7	65	--	--
rLLD	Lalaau extremely stony muck, 6 to 20 percent slopes	33	---	VIIs	--	--	10	65	14	71
rLV	Lava flows, Aa	34	---	VIIIs	--	--	--	--	--	--
rLW	Lava flows, pahoehoe	34	---	VIIIs	--	--	--	--	--	--
rMAD	Malama extremely stony muck, 3 to 15 percent slopes	37	---	VIIs	--	--	7	65	13	71
rMUB	Manu silt loam, 2 to 6 percent slopes	38	---	IIe	--	--	9	65	7	70
rMWD	Mawae extremely stony muck, 6 to 20 percent slopes	38	---	VIIs	--	--	12	66	14	71
rOPE	Opihikao extremely rocky muck, 3 to 25 percent slopes	43	---	VIIs	--	--	7	65	--	--
rPAE	Papai extremely stony muck, 3 to 25 percent slopes	46	---	VIIs	--	--	9	65	13	71
rPHB	Puhimau silt loam, 2 to 6 percent slopes	48	---	IIIs	--	--	10	65	11	70
rPXE	Puna extremely stony muck, 3 to 25 percent slopes	48	---	VIIs	--	--	7	65	13	71
rPYD	Punaluu extremely rocky peat, 6 to 20 percent slopes	48	---	VIIs	--	--	3	64	--	--
rRO	Rock land	51	---	VIIs	--	--	--	--	--	--
rVS	Very stony land	52	---	VIIs	--	--	--	--	--	--

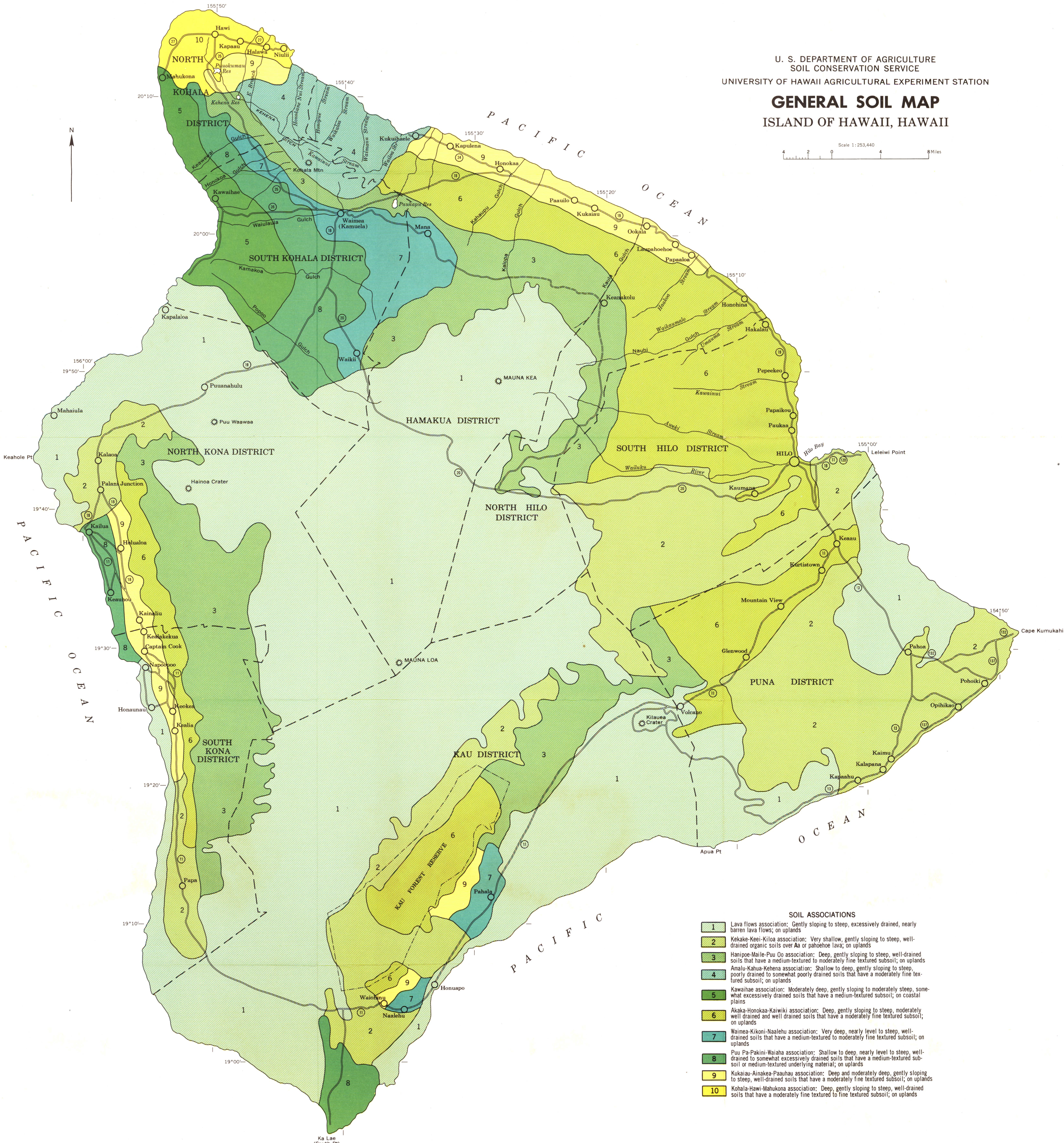
424-785 O - 73 (Face cover 3) No. 3

Accessibility Statement

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
UNIVERSITY OF HAWAII AGRICULTURAL EXPERIMENT STATION

GENERAL SOIL MAP

ISLAND OF HAWAII, HAWAII



SOIL ASSOCIATIONS

1 — Lava flows association: Gently sloping to steep, excessively drained, nearly barren lava flows; on uplands

2 — Kekake-Keei-Kiloa association: Very shallow, gently sloping to steep, well-drained organic soils over Aa or pahoehoe lava; on uplands

3 — Hanipoe-Maile-Puu Oo association: Deep, gently sloping to steep, well-drained soils that have a medium-textured to moderately fine textured subsoil; on uplands

4 — Amalu-Kahua-Kehena association: Shallow to deep, gently sloping to steep, poorly drained to somewhat poorly drained soils that have a moderately fine textured subsoil; on uplands

5 — Kawaihae association: Moderately deep, gently sloping to moderately steep, somewhat excessively drained soils that have a medium-textured subsoil; on coastal plains

6 — Akaka-Honokaa-Kaiwiki association: Deep, gently sloping to steep, moderately well drained and well drained soils that have a moderately fine textured subsoil; on uplands

7 — Waimea-Kikoni-Naalehu association: Very deep, nearly level to steep, well-drained soils that have a medium-textured to moderately fine textured subsoil; on uplands

8 — Puu Pa-Pakini-Waiaha association: Shallow to deep, nearly level to steep, well-drained to somewhat excessively drained soils that have a medium-textured subsoil or medium-textured underlying material; on uplands

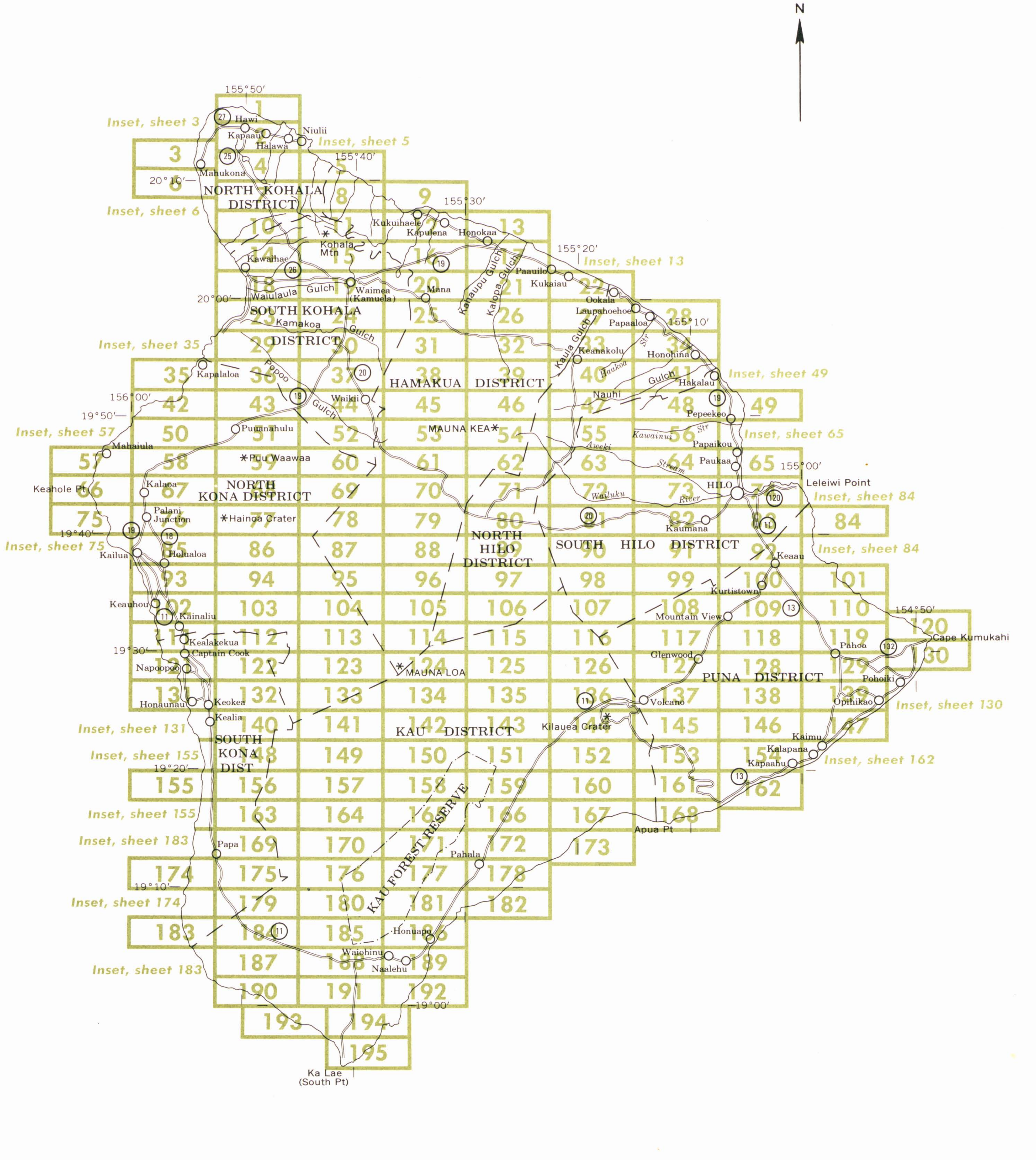
9 — Kukaiau-Ainakea-Paauhau association: Deep and moderately deep, gently sloping to steep, well-drained soils that have a moderately fine textured subsoil; on uplands

10 — Kohala-Hawi-Mahukona association: Deep, gently sloping to steep, well-drained soils that have a moderately fine textured to fine textured subsoil; on uplands

This map is for general planning. It shows only the major soils and does not contain sufficient detail for operational planning.

Published 1971

ISLAND OF HAWAII, HAWAII 26735 SPARTANBURG, S. C.



INDEX TO MAP SHEETS

ISLAND OF HAWAII, HAWAII

Scale 1:633,600

10 0 10 20 Miles

SOIL LEGEND

The first capital letter is the initial one of the soil name. The next letter is a capital if the mapping unit is one of the low intensity or reconnaissance surveys; it is a small letter if the mapping unit is one of the high intensity survey. The last letter, a capital A, B, C, D, E, or F, indicates the slope. Most symbols without a slope letter are those of soils and land types that have a considerable range in slope. A final number, 2 or 3, in the symbol indicates that the soil is eroded or severely eroded. The small letter "r" precedes the symbols for soils of the reconnaissance survey.

HIGH INTENSITY

SYMBOL	NAME
AaC	Ainakea silty clay loam, 3 to 12 percent slopes
AaD	Ainakea silty clay loam, 12 to 20 percent slopes
AaE	Ainakea silty clay loam, 20 to 35 percent slopes
AkC	Akaka silty clay loam, 0 to 10 percent slopes
AkD	Akaka silty clay loam, 10 to 20 percent slopes
AlC	Alapai silty clay loam, 0 to 10 percent slopes
AlD	Alapai silty clay loam, 10 to 20 percent slopes
AlE	Alapai silty clay loam, 20 to 35 percent slopes
ApD	Alapai extremely stony silty clay loam, 10 to 20 percent slopes
HaA	Hawi silty clay, 0 to 3 percent slopes
HaC	Hawi silty clay, 3 to 12 percent slopes
HeC	Hawi extremely stony silty clay, 6 to 12 percent slopes
HlC	Hilea silty clay loam, 6 to 12 percent slopes
HoC	Hilo silty clay loam, 0 to 10 percent slopes
HoD	Hilo silty clay loam, 10 to 20 percent slopes
HoE	Hilo silty clay loam, 20 to 35 percent slopes
HsC	Honokaa silty clay loam, low elevation, 0 to 10 percent slopes
HsD	Honokaa silty clay loam, low elevation, 10 to 20 percent slopes
HsE	Honokaa silty clay loam, low elevation, 20 to 35 percent slopes
KaC	Kaiwiki silty clay loam, 0 to 10 percent slopes
KaD	Kaiwiki silty clay loam, 10 to 20 percent slopes
KaE	Kaiwiki silty clay loam, 20 to 35 percent slopes
KfA	Kikoni very fine sandy loam, 0 to 3 percent slopes
KhA	Kohala silty clay, 0 to 3 percent slopes
KhC	Kohala silty clay, 3 to 12 percent slopes
KhD	Kohala silty clay, 12 to 20 percent slopes
KhE	Kohala silty clay, 20 to 35 percent slopes
KuC	Kukaiau silty clay loam, 6 to 12 percent slopes
KuD	Kukaiau silty clay loam, 12 to 20 percent slopes
KuE	Kukaiau silty clay loam, 20 to 35 percent slopes
KwD	Kukaiau silty clay loam, moderately shallow, 12 to 20 percent slopes
MaA	Maile silt loam, 0 to 3 percent slopes
MoC	Moaula silty clay loam, 0 to 10 percent slopes
MoD	Moaula silty clay loam, 10 to 20 percent slopes
MoE	Moaula silty clay loam, 20 to 35 percent slopes
NaC	Naalehu silty clay loam, 0 to 10 percent slopes
NaD	Naalehu silty clay loam, 10 to 20 percent slopes
NaE	Naalehu silty clay loam, 20 to 35 percent slopes
NhD	Naalehu very rocky silty clay loam, 6 to 20 percent slopes
NlC	Niulii silty clay loam, 6 to 12 percent slopes
NlD	Niulii silty clay loam, 12 to 20 percent slopes
NlE	Niulii silty clay loam, 20 to 35 percent slopes
OaC	Olaa silty clay loam, 0 to 10 percent slopes
OlD	Olaa extremely stony silty clay loam, 0 to 20 percent slopes
OoC	Ookala silty clay loam, 6 to 12 percent slopes
OoD	Ookala silty clay loam, 12 to 20 percent slopes
OoE	Ookala silty clay loam, 20 to 35 percent slopes
PaC	Paauhau silty clay loam, 6 to 12 percent slopes
PaD	Paauhau silty clay loam, 12 to 20 percent slopes
PaE	Paauhau silty clay loam, 20 to 35 percent slopes
PeC	Panaewa very rocky silty clay loam, 0 to 10 percent slopes
Tr	Tropaquepts

LOW INTENSITY

SYMBOL	NAME
AFD	Apakuie very fine sandy loam, 12 to 20 percent slopes
ASD	Apakuie very stony very fine sandy loam, 12 to 20 percent slopes

LOW INTENSITY

SYMBOL	NAME
BH	Beaches
FL	Fill land
HCD	Hanipoe very stony loam, 12 to 20 percent slopes
HDD	Hanipoe silt loam, 12 to 20 percent slopes
HFD	Hanipoe very rocky silt loam, 6 to 20 percent slopes
HHC	Heake very rocky sandy loam, 6 to 12 percent slopes
HKC	Heake extremely rocky sandy loam, 0 to 10 percent slopes
HND	Honaunau silt loam, 6 to 20 percent slopes
HRD	Honaunau extremely rocky silty clay loam, 6 to 20 percent slopes
HTD	Honokaa silty clay loam, 10 to 20 percent slopes
HTE	Honokaa silty clay loam, 20 to 35 percent slopes
HUD	Honuaulu very stony silty clay loam, 6 to 20 percent slopes
HVD	Honuaulu extremely stony silty clay loam, 12 to 20 percent slopes
KBC	Kaalualu extremely stony loamy sand, 2 to 12 percent slopes
KCD	Kahua silty clay loam, 6 to 20 percent slopes
KDD	Kainaliu very stony silty clay loam, 12 to 20 percent slopes
KEC	Kainaliu extremely stony silty clay loam, 12 to 20 percent slopes
KGC	Kamakoa very fine sandy loam, 0 to 10 percent slopes
KIC	Kamaoa loam, 6 to 12 percent slopes
KJC	Kamaoa loam, moderately shallow, 6 to 12 percent slopes
KKC	Kamaoa extremely stony loam, 6 to 12 percent slopes
KLC	Kapapala loam, 0 to 10 percent slopes
KLD	Kapapala loam, 10 to 20 percent slopes
KMD	Kapapala very rocky loam, 6 to 20 percent slopes
KNC	Kawaihae extremely stony very fine sandy loam, 6 to 12 percent slopes
KOC	Kawaihae very rocky very fine sandy loam, 6 to 12 percent slopes
KPD	Kealakekua silty clay loam, 12 to 20 percent slopes
KRD	Kealakekua very stony silty clay loam, 6 to 20 percent slopes
KSD	Kealakekua extremely stony silty clay loam, 12 to 20 percent slopes
KTB	Keekee loamy sand, 0 to 6 percent slopes
KVC	Kehena silty clay loam, 6 to 12 percent slopes
KXC	Kikoni very fine sandy loam, 3 to 12 percent slopes
KYC	Kikoni extremely stony very fine sandy loam, 6 to 12 percent slopes
KZD	Kilohana loamy fine sand, 12 to 20 percent slopes
LAD	Laumaia silt loam, 6 to 20 percent slopes
LUC	Laumaia extremely stony silt loam, 6 to 12 percent slopes
MHC	Mahukona silty clay loam, 3 to 12 percent slopes
MKC	Mahukona very stony silty clay loam, 6 to 12 percent slopes
MLD	Maile silt loam, 6 to 20 percent slopes
MMD	Manahaa silt loam, 6 to 20 percent slopes
MND	Manahaa extremely stony silt loam, 6 to 20 percent slopes
MT	Mixed alluvial land
OHC	Ohia silty clay loam, 0 to 10 percent slopes
OSD	Ohia extremely stony silty clay loam, 0 to 20 percent slopes
PKB	Pakini very fine sandy loam, 2 to 6 percent slopes
PLC	Palapalai silt loam, 6 to 12 percent slopes
PMC	Palapalai silty clay loam, 6 to 12 percent slopes
PND	Piihonua silty clay loam, 6 to 20 percent slopes
POD	Piihonua extremely stony silty clay loam, 6 to 20 percent slopes
PPC	Puaulu silt loam, 0 to 10 percent slopes
PRD	Punohu silt loam, 12 to 20 percent slopes
PSC	Puukala extremely stony silt loam, 6 to 12 percent slopes
PTC	Puukala very rocky silt loam, 6 to 12 percent slopes
PUC	Puu Oo silt loam, 6 to 12 percent slopes
PVD	Puu Pa extremely stony very fine sandy loam, 6 to 20 percent slopes
PVF3	Puu Pa extremely stony very fine sandy loam, 70 to 100 percent slopes, severely eroded
PWD	Puu Pa silt loam, 12 to 20 percent slopes

LOW INTENSITY

SYMBOL	NAME
RB	Rough broken land
UMD	Umikoa silt loam, 12 to 20 percent slopes
USD	Umikoa extremely stony silt loam, 12 to 20 percent slopes
WAC	Waiaha silt loam, 0 to 10 percent slopes
WAD	Waiaha silt loam, 10 to 20 percent slopes
WHC	Waiaha extremely stony silt loam, 6 to 12 percent slopes
WKD	Waiaha very rocky silt loam, 10 to 20 percent slopes
WLC	Waikaloa very fine sandy loam, 6 to 12 percent slopes
WMC	Waimea very fine sandy loam, 6 to 12 percent slopes
WSD	Waimea extremely stony very fine sandy loam, 12 to 20 percent slopes

RECONNAISSANCE

SYMBOL	NAME
rAK	Akaka soils
rAM	Amalu soils
rAR	Amalu-Rough broken land association
rCL	Cinder land
rHID	Huikau loamy sand, 12 to 20 percent slopes
rHID2	Huikau loamy sand, 12 to 20 percent slopes, eroded
rHLD	Huikau extremely stony loamy sand, 12 to 20 percent slopes
rHP	Hydrandept-Tropofolist association
rKAD	Kahaluu extremely rocky muck, 6 to 20 percent slopes
rKED	Kaimu extremely stony peat, 6 to 20 percent slopes
rKFD	Keaukaha extremely rocky muck, 6 to 20 percent slopes
rKGD	Keei extremely rocky muck, 6 to 20 percent slopes
rKHD	Kekake extremely rocky muck, 6 to 20 percent slopes
rKUC	Kilauea extremely gravelly sand, 6 to 12 percent slopes
rKXD	Kiloa extremely stony muck, 6 to 20 percent slopes
rKYD	Kona extremely rocky muck, 6 to 20 percent slopes
rLLD	Lalaau extremely stony muck, 6 to 20 percent slopes
rLV	Lava flows, Aa
rLW	Lava flows, pahoehoe
rMAD	Malama extremely stony muck, 3 to 15 percent slopes
rMUB	Manu silt loam, 2 to 6 percent slopes
rMWD	Mawae extremely stony muck, 6 to 20 percent slopes
rOPE	Opihikao extremely rocky muck, 3 to 25 percent slopes
rPAE	Papai extremely stony muck, 3 to 25 percent slopes
rPHB	Puhimau silt loam, 2 to 6 percent slopes
rPXE	Puna extremely stony muck, 3 to 25 percent slopes
rPYD	Punaluu extremely rocky peat, 6 to 20 percent slopes
rRO	Rock land
rVS	Very stony land

CONVENTIONAL SIGNS

WORKS AND STRUCTURES

Highways and roads
- Dual
- Good motor
- Poor motor
- Trail

Highway markers
- National Interstate
- U. S.
- State or county

Railroads
- Single track
- Multiple track
- Abandoned

Bridges and crossings
- Road
- Trail
- Railroad
- Ferry — FY
- Ford — FORD
- Grade
- R. R. over
- R. R. under

Tunnel

Buildings

School

Church

Mine and quarry

Gravel pit

Power line

Pipeline

Cemetery

Dams

Levee

Tanks

Lighthouse

Forest fire or lookout station

Windmill

BOUNDARIES

National or state

County

Reservation

Land grant

Small park, cemetery, airport

DRAINAGE

Streams, double-line
- Perennial
- Intermittent

Streams, single-line
- Perennial
- Intermittent
  - Crossable with tillage implements
  - Not crossable with tillage implements
  - Unclassified

Canals and ditches — CANAL

Lakes and ponds
- Perennial — water, w
- Intermittent — int

Spring

Marsh or swamp

Wet spot

Alluvial fan

Drainage end

RELIEF

Escarpments
- Bedrock
- Other

Prominent peak

Depressions (Large, Small)
- Crossable with tillage implements
- Not crossable with tillage implements
- Contains water most of the time

SOIL SURVEY DATA

Soil boundary and symbol — Dx

Gravel

Stoniness
- Stony
- Very stony

Rock outcrops

Chert fragments

Clay spot

Sand spot

Gumbo or scabby spot

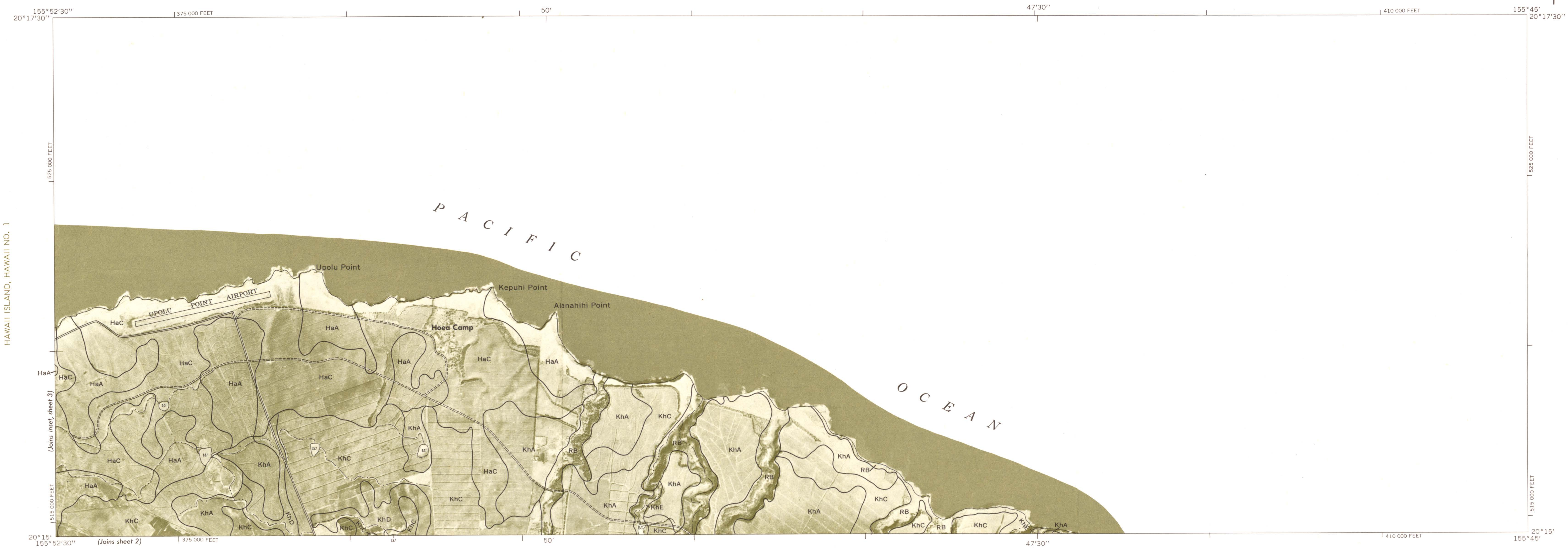
Made land

Severely eroded spot

Blowout, wind erosion

Gully

1



HAWAII ISLAND, HAWAII NO. 1

This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the University of Hawaii Agricultural Experiment Station.

Photobase from 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 1. Old Hawaiian datum.

Scale 1:24 000

Scale 1:24 000

1 ¾ ½ ¼ 0 1 2 Miles

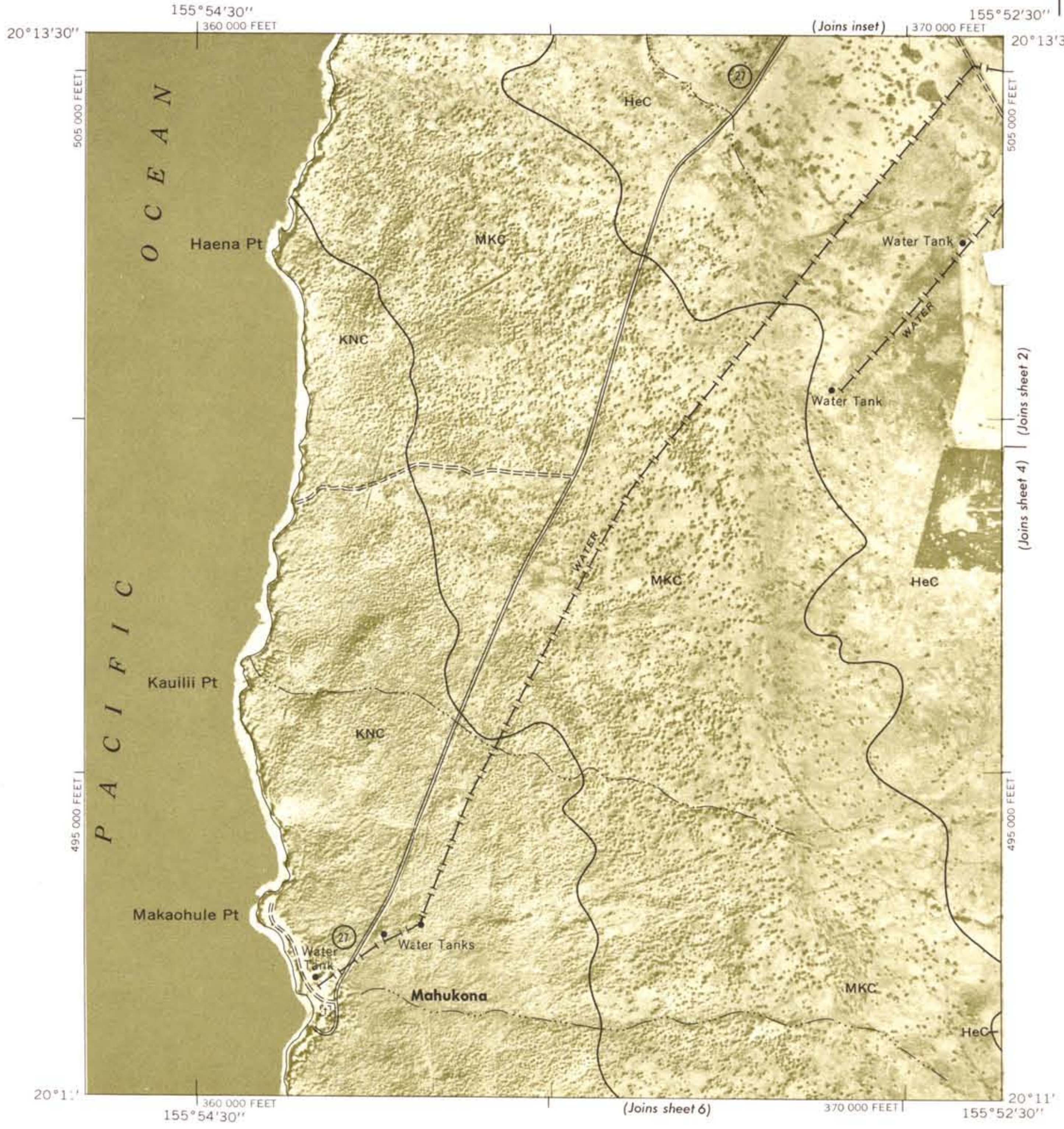
5000 4000 3000 2000 1000 0 5000 10000 Feet

Photobase from 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 1. Old Hawaiian datum.

This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the University of Hawaii Agricultural Experiment Station.

This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the University of Hawaii Agricultural Experiment Station.

HAWAII ISLAND, HAWAII NO. 3



N

Photobase from 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 1. Old Hawaiian datum.

Scale 1:24 000

1 ¾ ½ ¼ 0 1 2 Miles

5000 4000 3000 2000 1000 0 5000 10000 Feet

N

Scale 1:24 000

1 ¾ ½ ¼ 0 1 2 Miles

5000 4000 3000 2000 1000 0 5000 10000 Feet

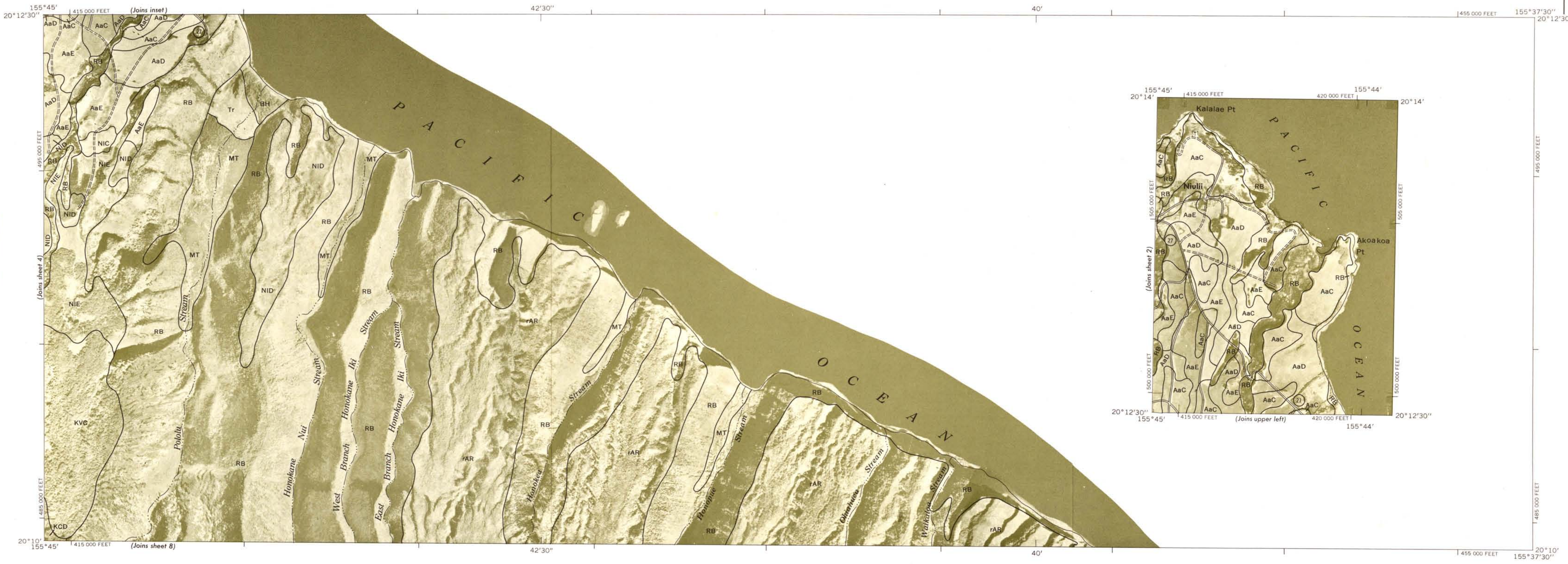
Photobase from 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 1. Old Hawaiian datum.

HAWAII ISLAND, HAWAII NO. 4

This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the University of Hawaii Agricultural Experiment Station

5

This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the University of Hawaii Agricultural Experiment Station.



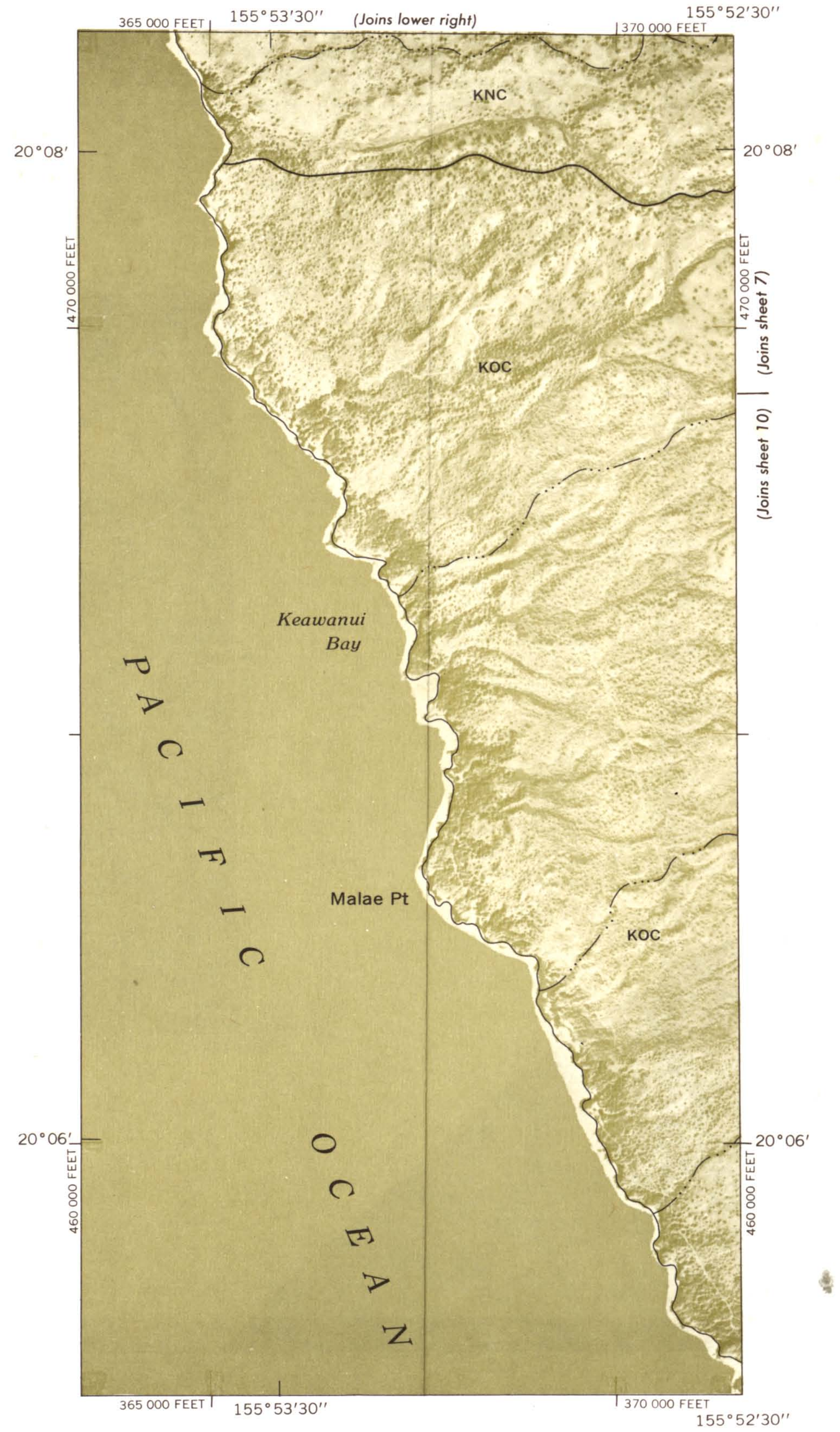
Photobase from 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 1. Old Hawaiian datum.

Scale 1:24 000

1 ¾ ½ ¼ 0 1 2 Miles

5000 4000 3000 2000 1000 0 5000 10000 Feet

N



Scale 1:24 000

1 ¾ ½ ¼ 0 1 2 Miles

5000 4000 3000 2000 1000 0 5000 10000 Feet

Photobase from 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 1. Old Hawaiian datum.

HAWAII ISLAND, HAWAII NO. 6

This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the University of Hawaii Agricultural Experiment Station.

7

This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the University of Hawaii Agricultural Experiment Station.

HAWAII ISLAND, HAWAII NO. 7

Photobase from 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 1. Old Hawaiian datum.

Scale 1:24 000

1 ¾ ½ ¼ 0 1 2 Miles

5000 4000 3000 2000 1000 0 5000 10000 Feet

HAWAII ISLAND, HAWAII — SHEET NUMBER 8

Scale 1:24 000

1 ¾ ½ ¼ 0 1 2 Miles

5000 4000 3000 2000 1000 0 5000 10000 Feet

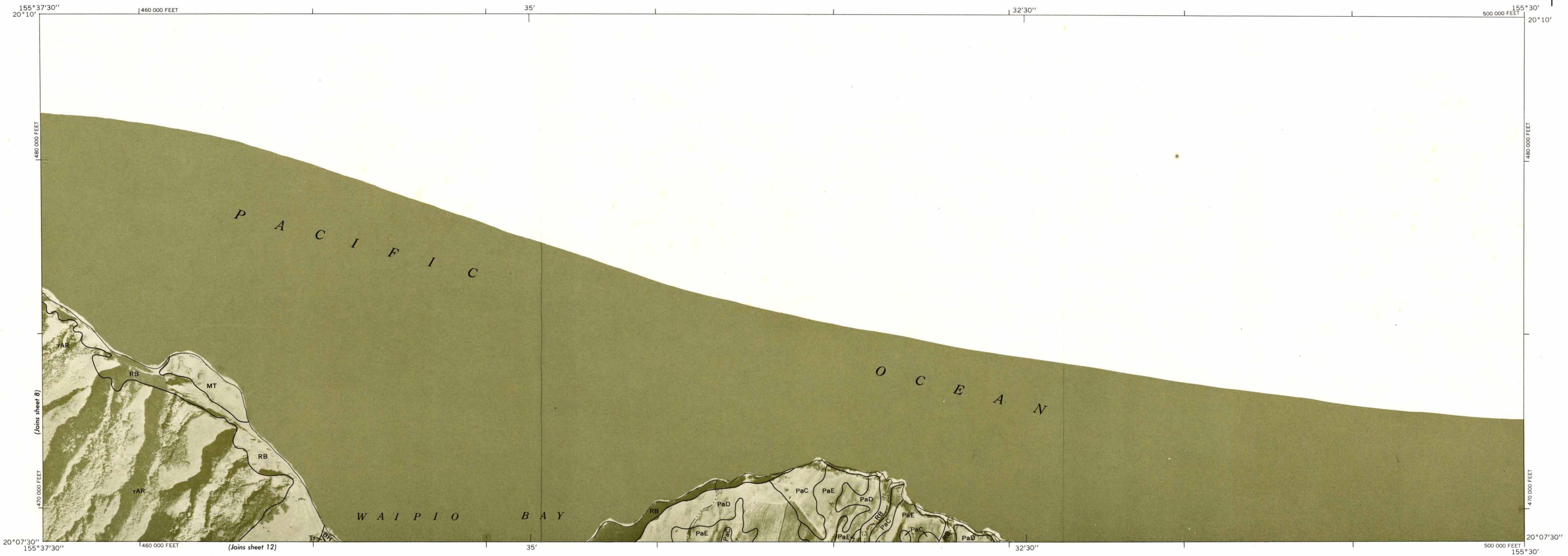
Photobase from 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 1. Old Hawaiian datum.

HAWAII ISLAND, HAWAII NO. 8

This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the University of Hawaii Agricultural Experiment Station.

9

N



Photobase from 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 1. Old Hawaiian datum.

Scale 1:24 000

1 ¾ ½ ¼ 0 1 2 Miles

5000 4000 3000 2000 1000 0 5000 10000 Feet

HAWAII ISLAND, HAWAII NO. 9

This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the University of Hawaii Agricultural Experiment Station.

Scale 1:24 000

1 ¾ ½ ¼ 0 1 2 Miles

5000 4000 3000 2000 1000 0 5000 10000 Feet

Photobase from 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 1. Old Hawaiian datum.

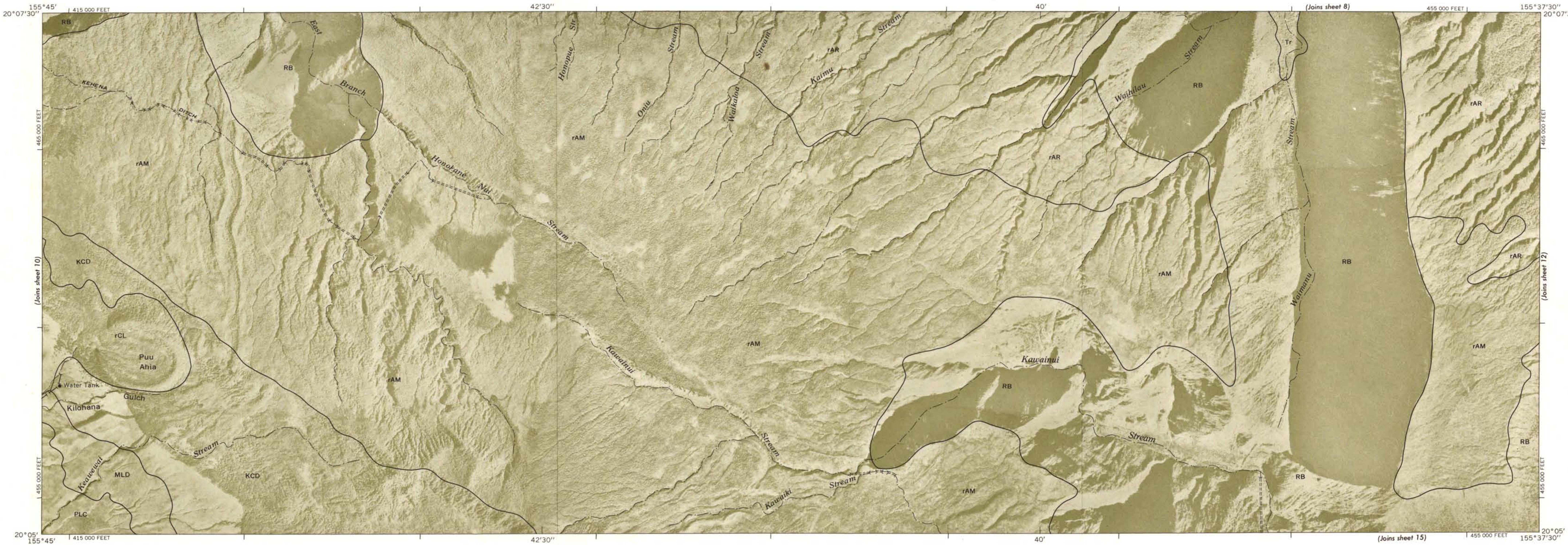
HAWAII ISLAND, HAWAII NO. 10

This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the University of Hawaii Agricultural Experiment Station.

HAWAII ISLAND, HAWAII — SHEET NUMBER 11

11

N



This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the University of Hawaii Agricultural Experiment Station.

HAWAII ISLAND, HAWAII NO. 11

Photobase from 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 1. Old Hawaiian datum.

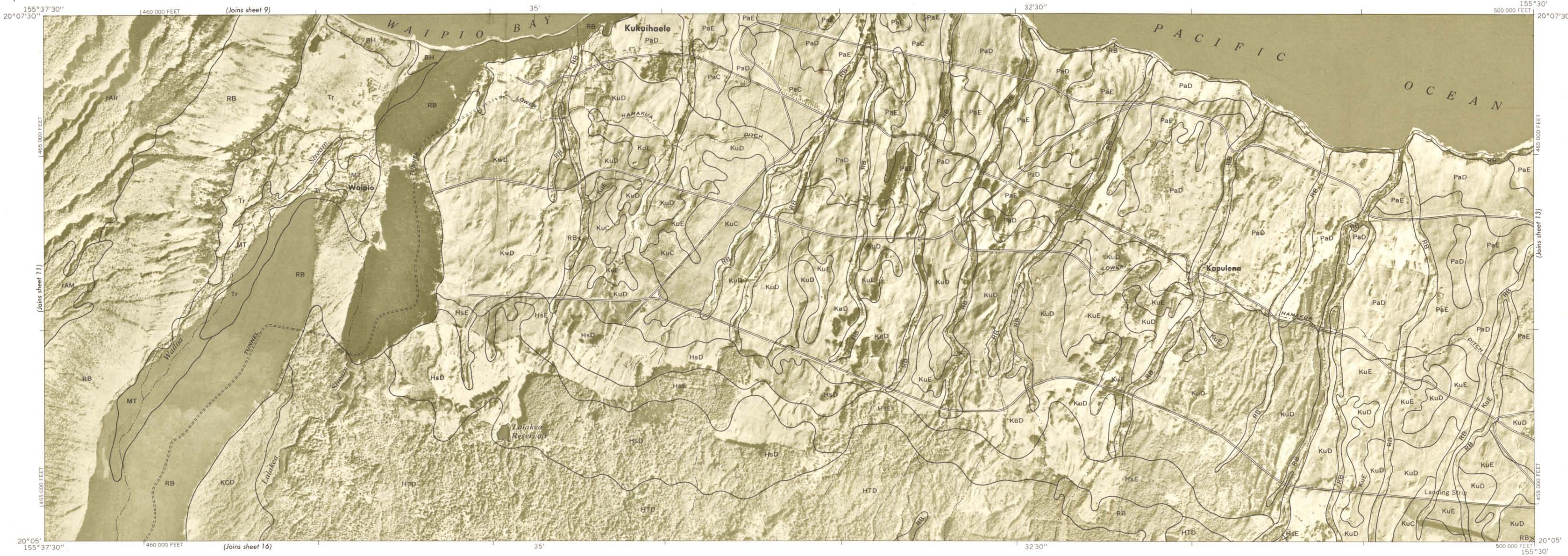
Scale 1:24 000

1 ¾ ½ ¼ 0 1 2 Miles

5000 4000 3000 2000 1000 0 5000 10000 Feet

HAWAII ISLAND, HAWAII — SHEET NUMBER 12

N



Scale 1:24 000

1 ¾ ½ ¼ 0 1 2 Miles

5000 4000 3000 2000 1000 0 5000 10000 Feet

Photobase from 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 1. Old Hawaiian datum.

HAWAII ISLAND, HAWAII NO. 12

This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the University of Hawaii Agricultural Experiment Station.

HAWAII ISLAND, HAWAII NO. 13

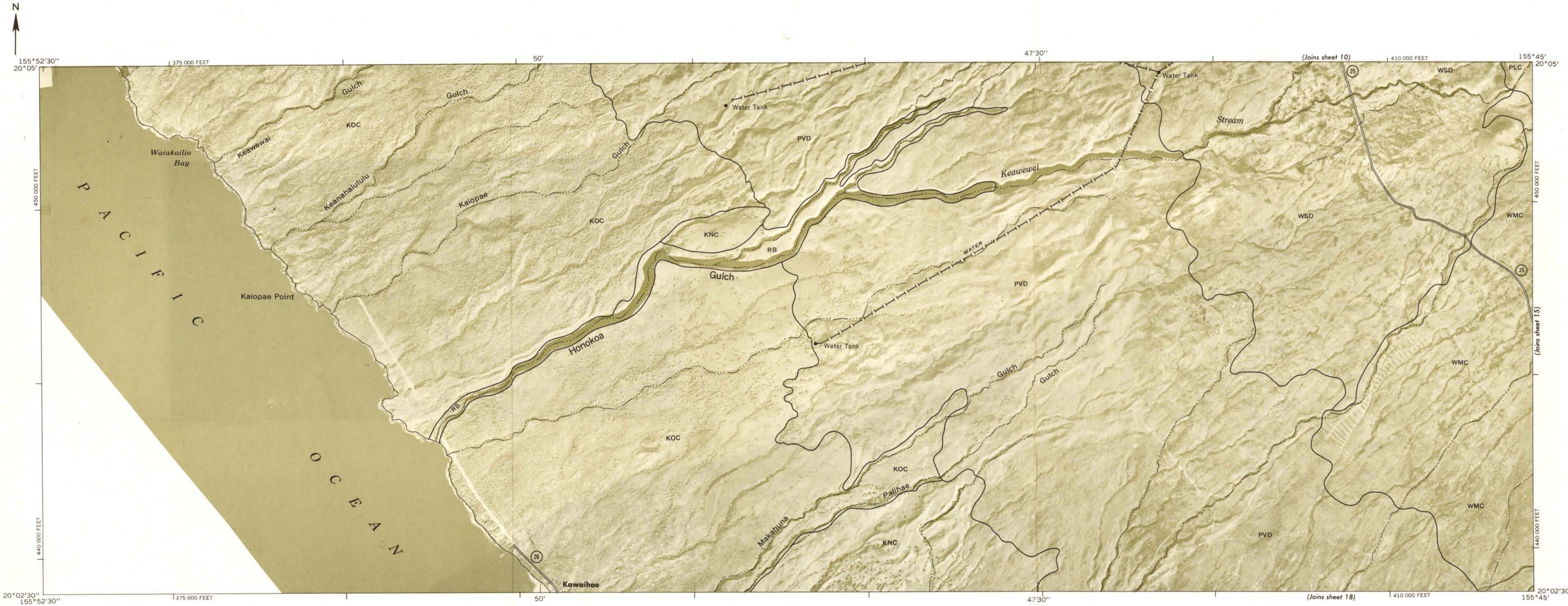
This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the University of Hawaii Agricultural Experiment Station.

Photobase from 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 1. Old Hawaiian datum.

Scale 1:24 000

1 ¾ ½ ¼ 0 1 2 Miles

5000 4000 3000 2000 1000 0 5000 10000 Feet



Scale 1:24 000

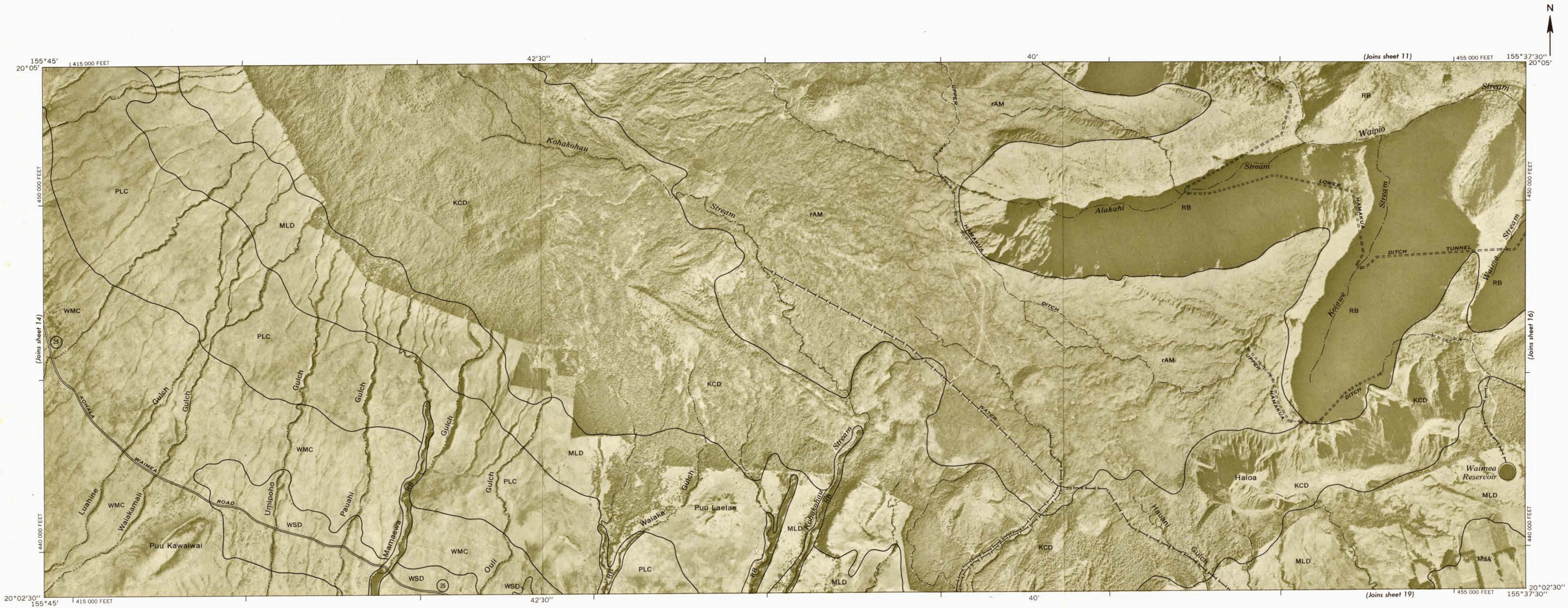
1 ¾ ½ ¼ 0 1 2 Miles

5000 4000 3000 2000 1000 0 5000 10000 Feet

Photobase from 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 1. Old Hawaiian datum.

HAWAII ISLAND, HAWAII NO. 14

This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the University of Hawaii Agricultural Experiment Station.



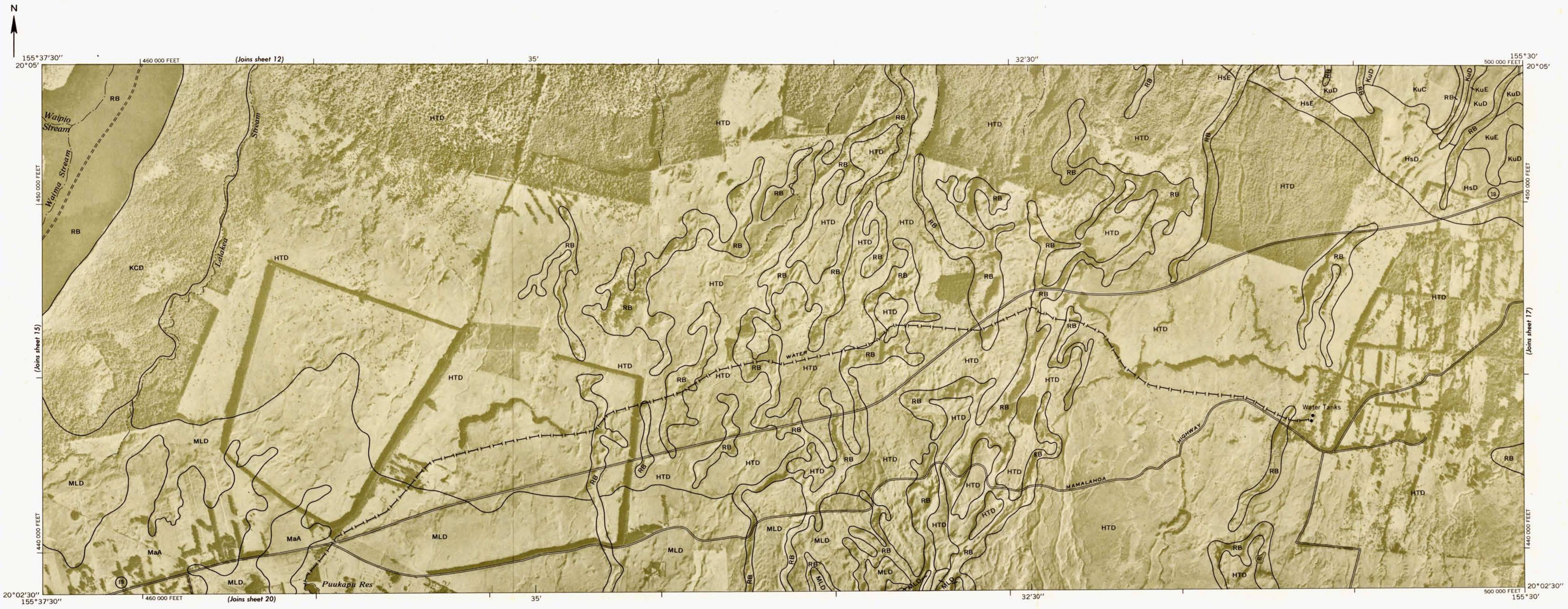
This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the University of Hawaii Agricultural Experiment Station

Photobase from 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 1. Old Hawaiian datum.

Scale 1:24 000

1 ¾ ½ ¼ 0 1 2 Miles

5000 4000 3000 2000 1000 0 5000 10000 Feet



Scale 1:24 000

1 ¾ ½ ¼ 0 1 2 Miles

5000 4000 3000 2000 1000 0 5000 10000 Feet

Photobase from 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 1. Old Hawaiian datum.

HAWAII ISLAND, HAWAII NO. 16

This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the University of Hawaii Agricultural Experiment Station.

17

N

This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the University of Hawaii Agricultural Experiment Station.

HAWAII ISLAND, HAWAII NO. 17

155°30′ 20°05′ 500 000 FEET (Joins sheet 13) 27′30″ 25′ 540 000 FEET 155°22′30″ 20°05′

450 000 FEET 440 000 FEET (Joins sheet 16) (Joins inset, sheet 13)

20°02′30″ 155°30′ 500 000 FEET (Joins sheet 21) 27′30″ 25′ 540 000 FEET 20°02′30″ 155°22′30″

Photobase from 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 1. Old Hawaiian datum.

Scale 1:24 000

1 ¾ ½ ¼ 0 1 2 Miles

5000 4000 3000 2000 1000 0 5000 10000 Feet

HAWAII ISLAND, HAWAII — SHEET NUMBER 18

Scale 1:24 000

1 ¾ ½ ¼ 0 1 2 Miles

5000 4000 3000 2000 1000 0 5000 10000 Feet

Photobase from 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 1. Old Hawaiian datum.

HAWAII ISLAND, HAWAII NO. 18

This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the University of Hawaii Agricultural Experiment Station.

N

Photobase from 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 1. Old Hawaiian datum.

Scale 1:24 000

1 ¾ ½ ¼ 0 1 2 Miles

5000 4000 3000 2000 1000 0 5000 10000 Feet

This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the University of Hawaii Agricultural Experiment Station.

HAWAII ISLAND, HAWAII NO. 19

20

N

HAWAII ISLAND, HAWAII — SHEET NUMBER 20

Scale 1:24 000

1 ¾ ½ ¼ 0 1 2 Miles

5000 4000 3000 2000 1000 0 5000 10000 Feet

Photobase from 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 1. Old Hawaiian datum.

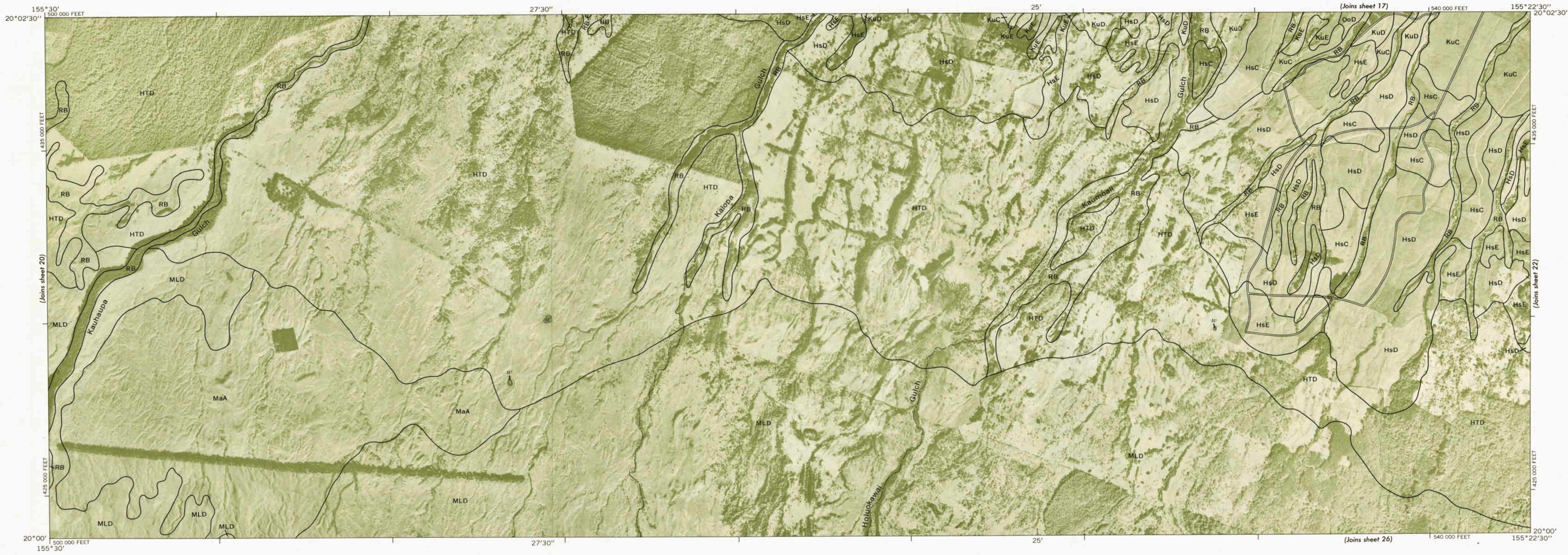
HAWAII ISLAND, HAWAII NO. 20

This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the University of Hawaii Agricultural Experiment Station.

21

This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the University of Hawaii Agricultural Experiment Station.

HAWAII ISLAND, HAWAII NO. 21



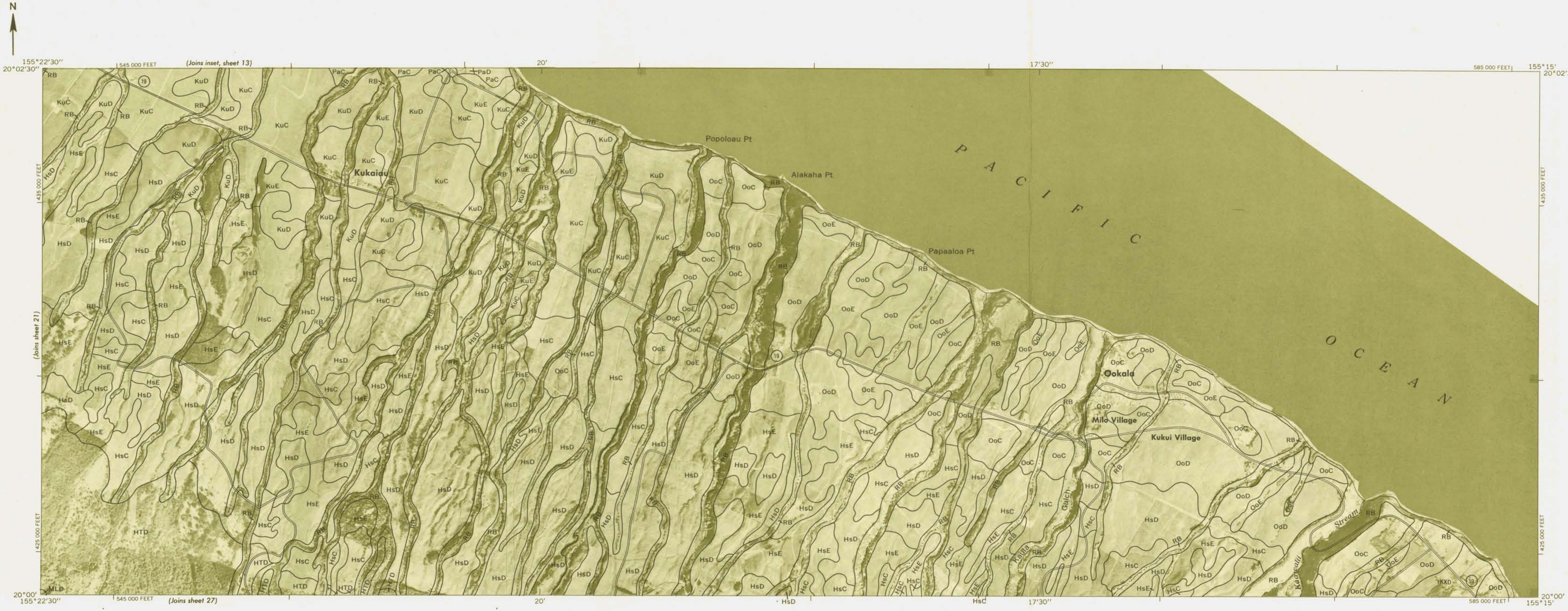
Photobase from 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 1. Old Hawaiian datum.

Scale 1:24 000

1 ¾ ½ ¼ 0 1 2 Miles

5000 4000 3000 2000 1000 0 5000 10000 Feet

HAWAII ISLAND, HAWAII — SHEET NUMBER 22



Scale 1:24 000

1 ¾ ½ ¼ 0 1 2 Miles

5000 4000 3000 2000 1000 0 5000 10000 Feet

Photobase from 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 1. Old Hawaiian datum.

HAWAII ISLAND, HAWAII NO. 22

This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the University of Hawaii Agricultural Experiment Station.

N

HAWAII ISLAND, HAWAII NO. 23

This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the University of Hawaii Agricultural Experiment Station.

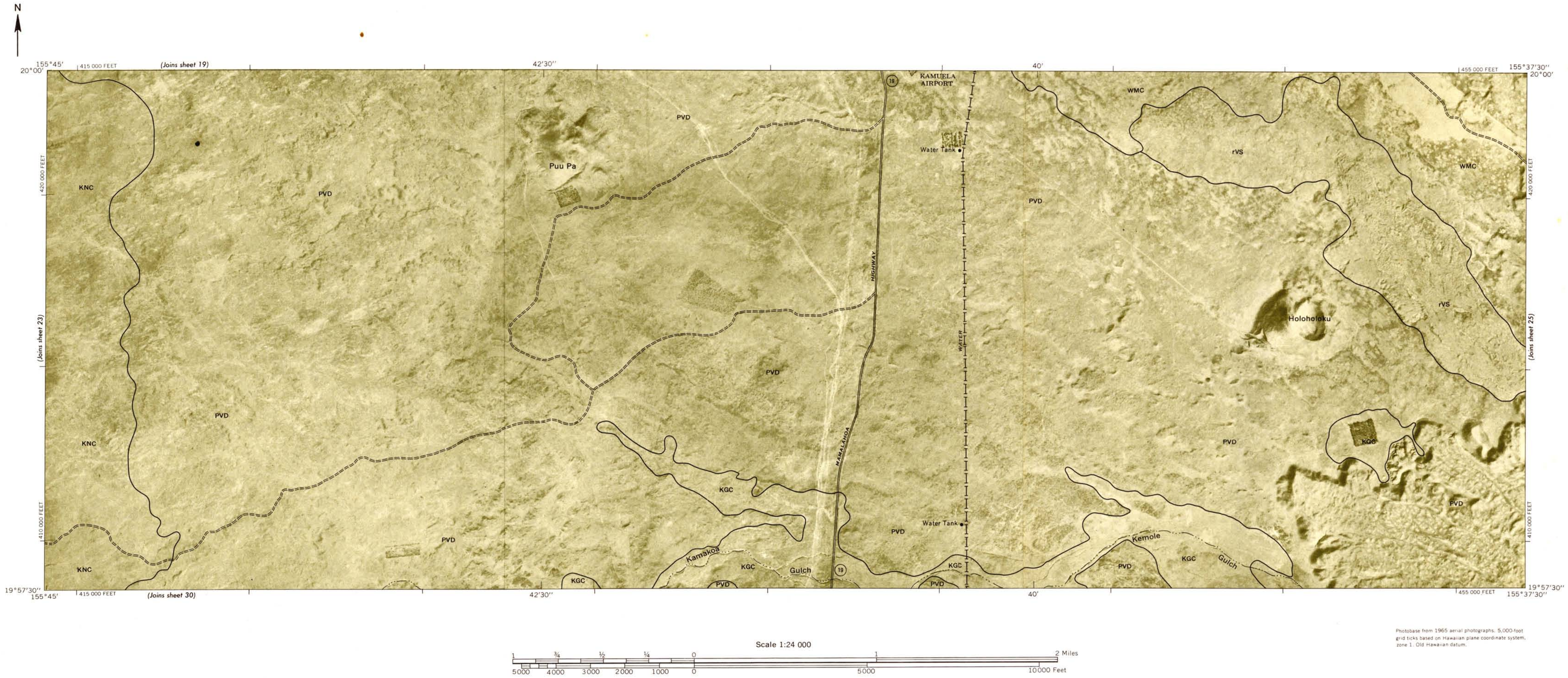
Photobase from 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 1. Old Hawaiian datum.

Scale 1:24 000

1 ¾ ½ ¼ 0 1 2 Miles

5000 4000 3000 2000 1000 0 5000 10000 Feet

HAWAII ISLAND, HAWAII — SHEET NUMBER 24



Photobase from 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 1. Old Hawaiian datum.

HAWAII ISLAND, HAWAII NO. 24

This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the University of Hawaii Agricultural Experiment Station.

This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the University of Hawaii Agricultural Experiment Station.

HAWAII ISLAND, HAWAII NO. 25

N

Photobase from 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 1. Old Hawaiian datum.

Scale 1:24 000

1 ¾ ½ ¼ 0 1 2 Miles

5000 4000 3000 2000 1000 0 5000 10000 Feet

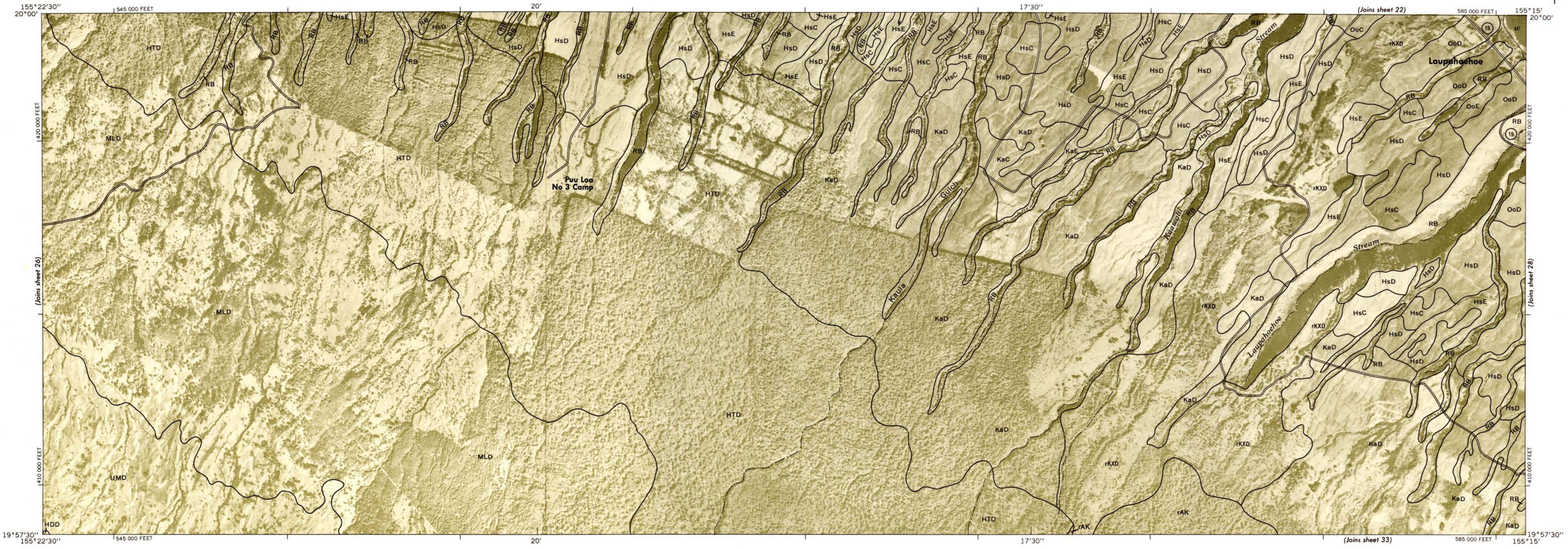
HAWAII ISLAND, HAWAII — SHEET NUMBER 26

Photobase from 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 1. Old Hawaiian datum.

HAWAII ISLAND, HAWAII NO. 26

This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the University of Hawaii Agricultural Experiment Station.

N



This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the University of Hawaii Agricultural Experiment Station.

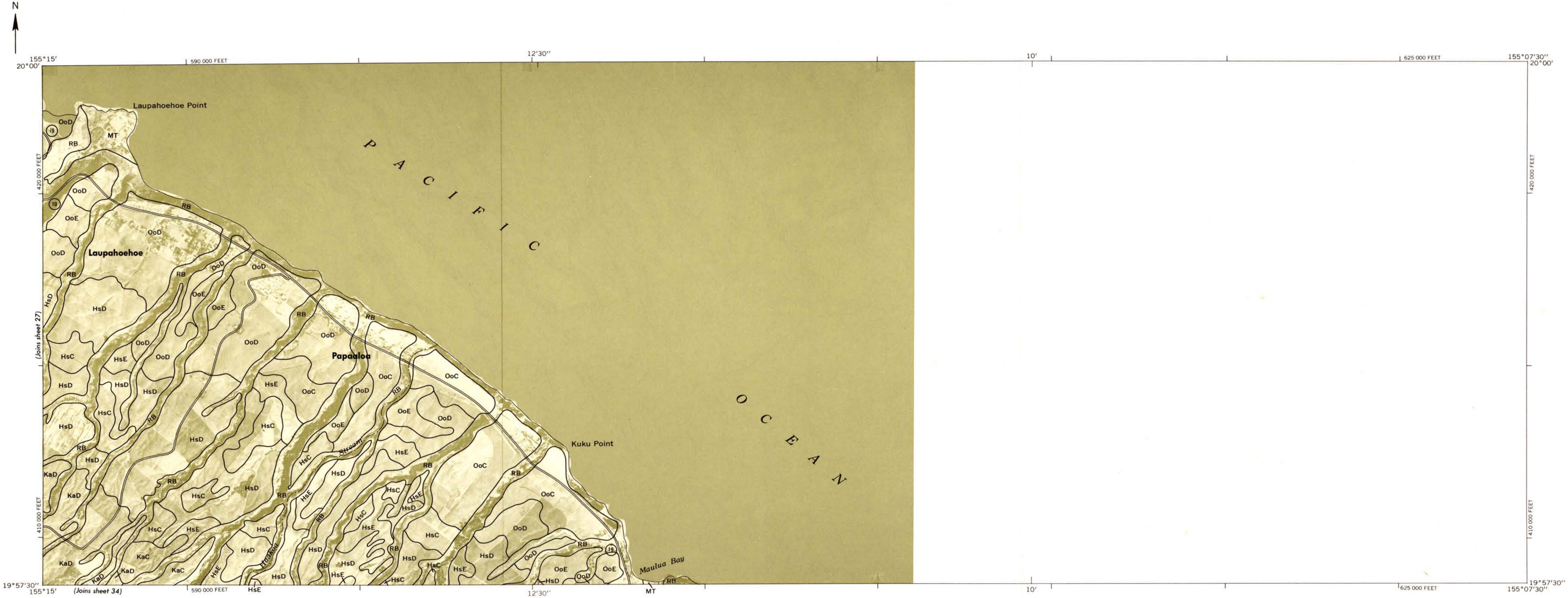
HAWAII ISLAND, HAWAII NO. 27

Photobase from 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 1. Old Hawaiian datum.

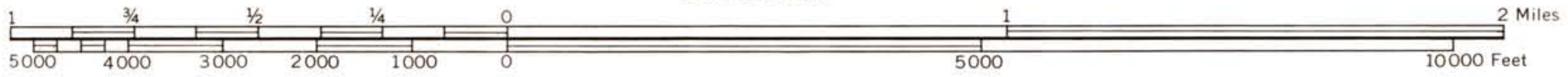
Scale 1:24 000

1 ¾ ½ ¼ 0 1 2 Miles

5000 4000 3000 2000 1000 0 5000 10000 Feet



Scale 1:24 000



Photobase from 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 1. Old Hawaiian datum.

HAWAII ISLAND, HAWAII NO. 28

This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the University of Hawaii Agricultural Experiment Station.

This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the University of Hawaii Agricultural Experiment Station.

Photobase from 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 1. Old Hawaiian datum.

Scale 1:24 000

1 ¾ ½ ¼ 0 1 2 Miles

5000 4000 3000 2000 1000 0 5000 10000 Feet

HAWAII ISLAND, HAWAII — SHEET NUMBER 30

Scale 1:24 000

1 ¾ ½ ¼ 0 1 2 Miles

5000 4000 3000 2000 1000 0 5000 10000 Feet

Photobase from 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 1. Old Hawaiian datum.

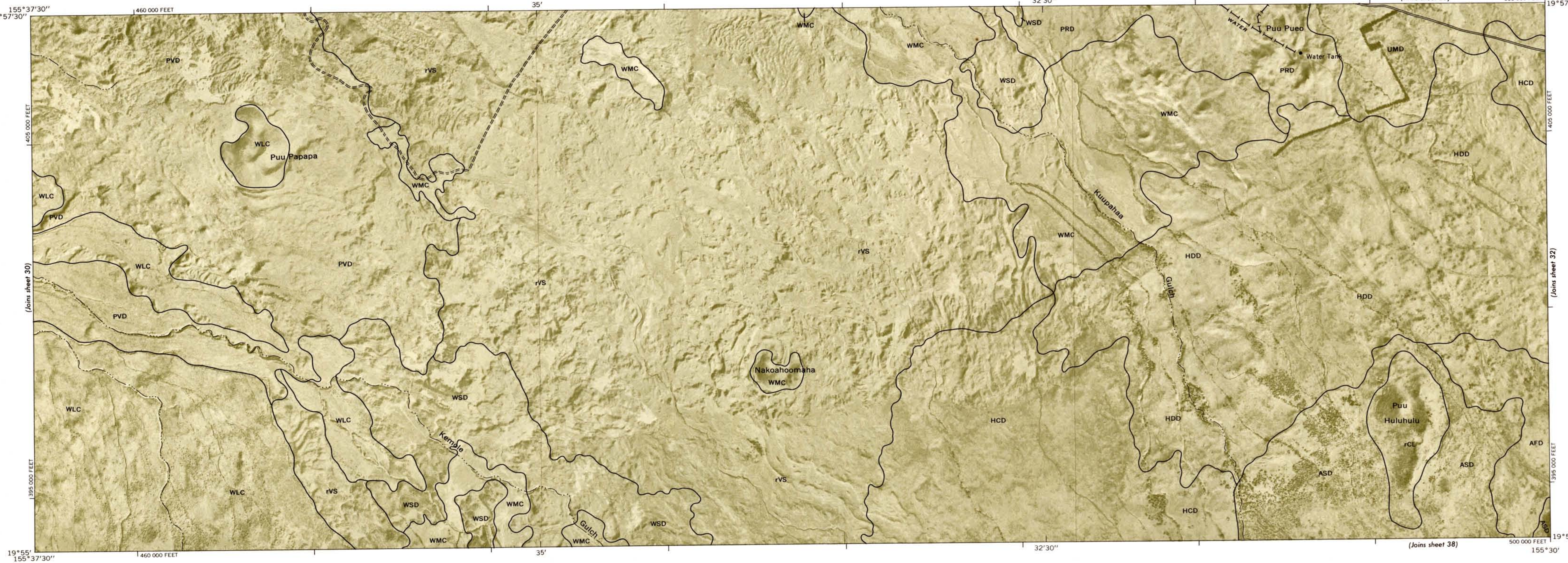
HAWAII ISLAND, HAWAII NO. 30

This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the University of Hawaii Agricultural Experiment Station.

This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the University of Hawaii Agricultural Experiment Station.

HAWAII ISLAND, HAWAII NO. 31

N



Photobase from 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 1. Old Hawaiian datum.

Scale 1:24 000

1 ¾ ½ ¼ 0 1 2 Miles

5000 4000 3000 2000 1000 0 5000 10000 Feet

Photobase from 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 1. Old Hawaiian datum.

Scale 1:24 000

1 ¾ ½ ¼ 0 1 2 Miles

5000 4000 3000 2000 1000 0 5000 10000 Feet

HAWAII ISLAND, HAWAII NO. 32

This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the University of Hawaii Agricultural Experiment Station.

33

N

This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the University of Hawaii Agricultural Experiment Station.

HAWAII ISLAND, HAWAII NO. 33

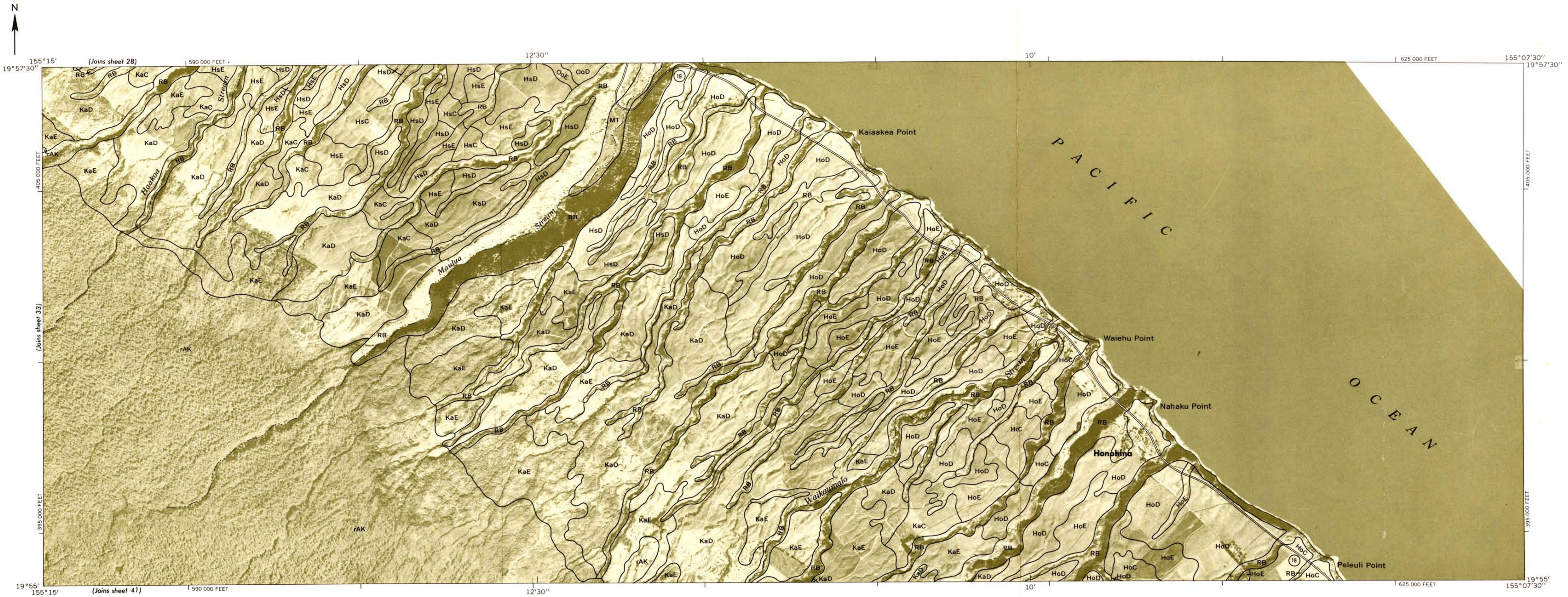
Photobase from 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 1. Old Hawaiian datum.

Scale 1:24 000

1 ¾ ½ ¼ 0 1 2 Miles

5000 4000 3000 2000 1000 0 5000 10000 Feet

HAWAII ISLAND, HAWAII — SHEET NUMBER 34



Scale 1:24 000

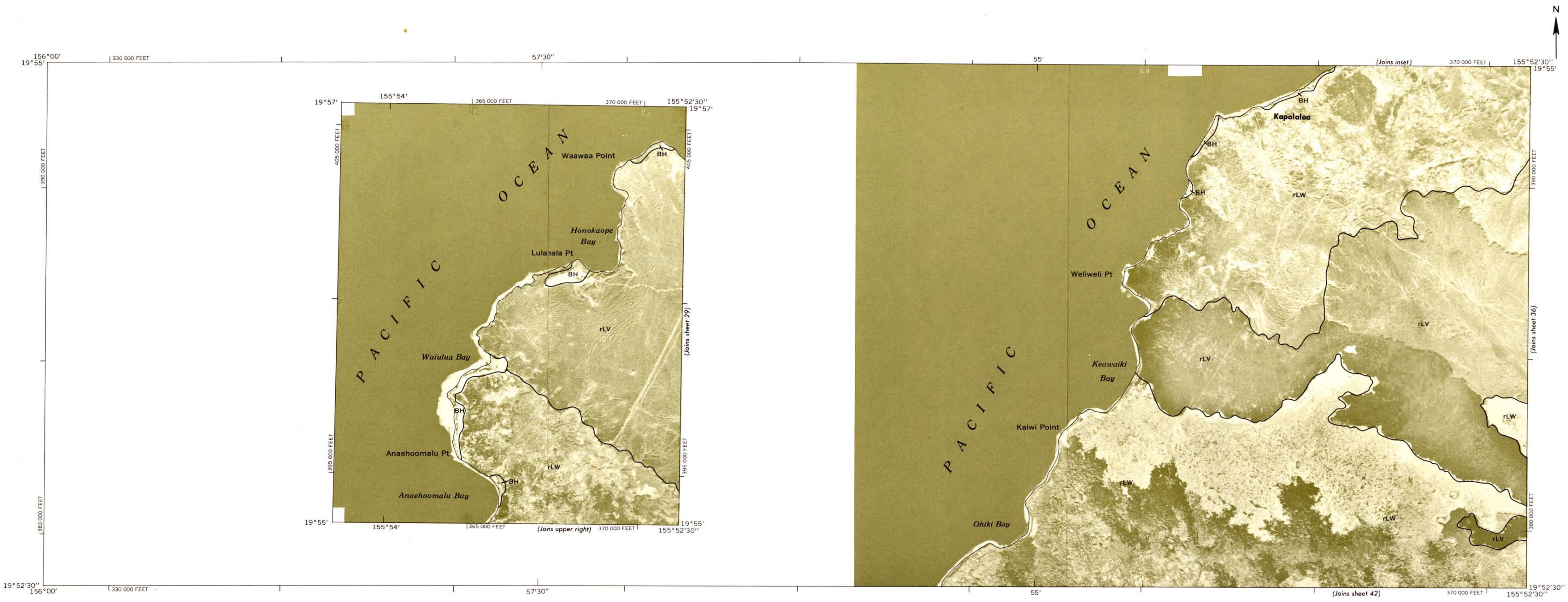
1 ¾ ½ ¼ 0 1 2 Miles

5000 4000 3000 2000 1000 0 5000 10000 Feet

Photobase from 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 1. Old Hawaiian datum.

HAWAII ISLAND, HAWAII NO. 34

This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the University of Hawaii Agricultural Experiment Station.



This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the University of Hawaii Agricultural Experiment Station.

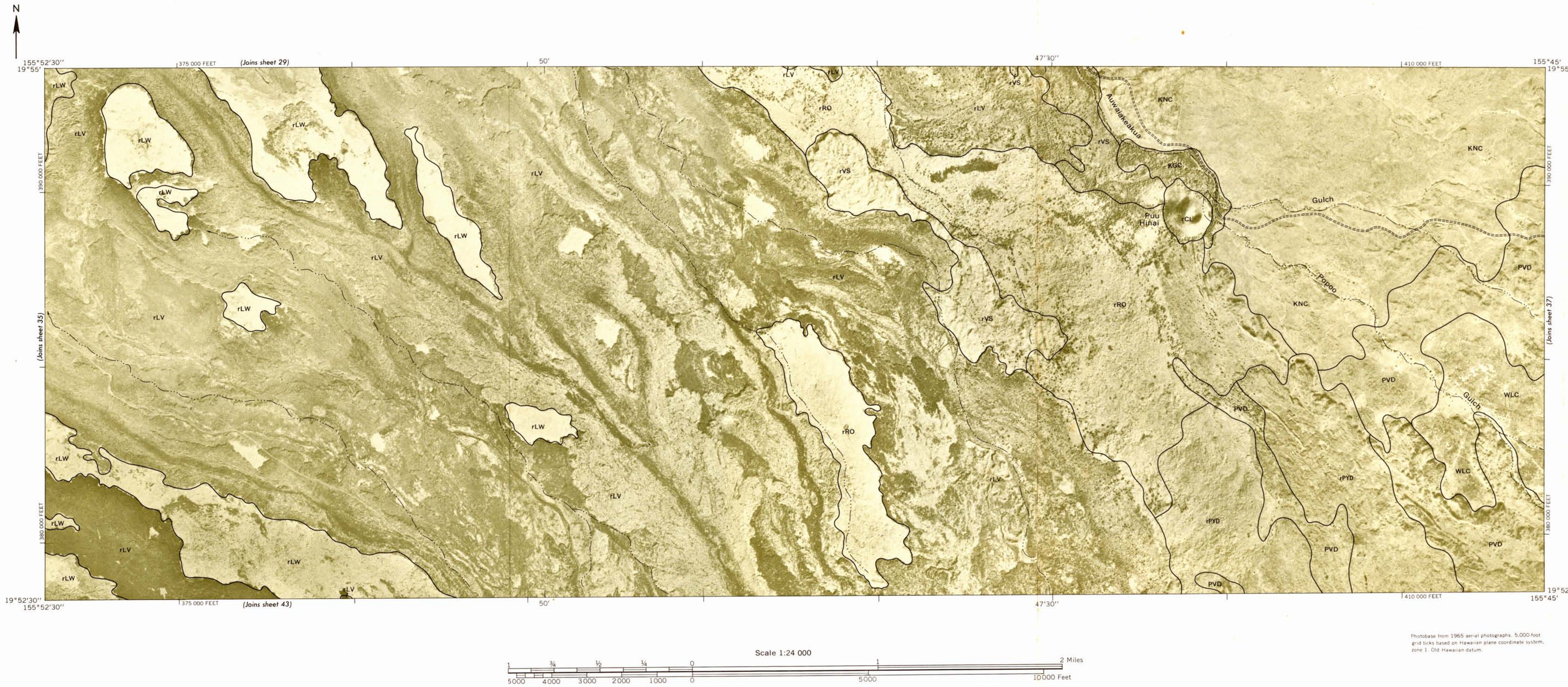
HAWAII ISLAND, HAWAII NO. 35

Photobase from 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 1. Old Hawaiian datum.

Scale 1:24 000

1 ¾ ½ ¼ 0 1 2 Miles

5000 4000 3000 2000 1000 0 5000 10000 Feet



Photobase from 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 1. Old Hawaiian datum.

HAWAII ISLAND, HAWAII NO. 36

This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the University of Hawaii Agricultural Experiment Station.

37

N

This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the University of Hawaii Agricultural Experiment Station.

HAWAII ISLAND, HAWAII NO. 37

Photobase from 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 1. Old Hawaiian datum.

Scale 1:24 000

1 ¾ ½ ¼ 0 1 2 Miles

5000 4000 3000 2000 1000 0 5000 10000 Feet

Scale 1:24 000

1 ¾ ½ ¼ 0 1 2 Miles

5000 4000 3000 2000 1000 0 5000 10000 Feet

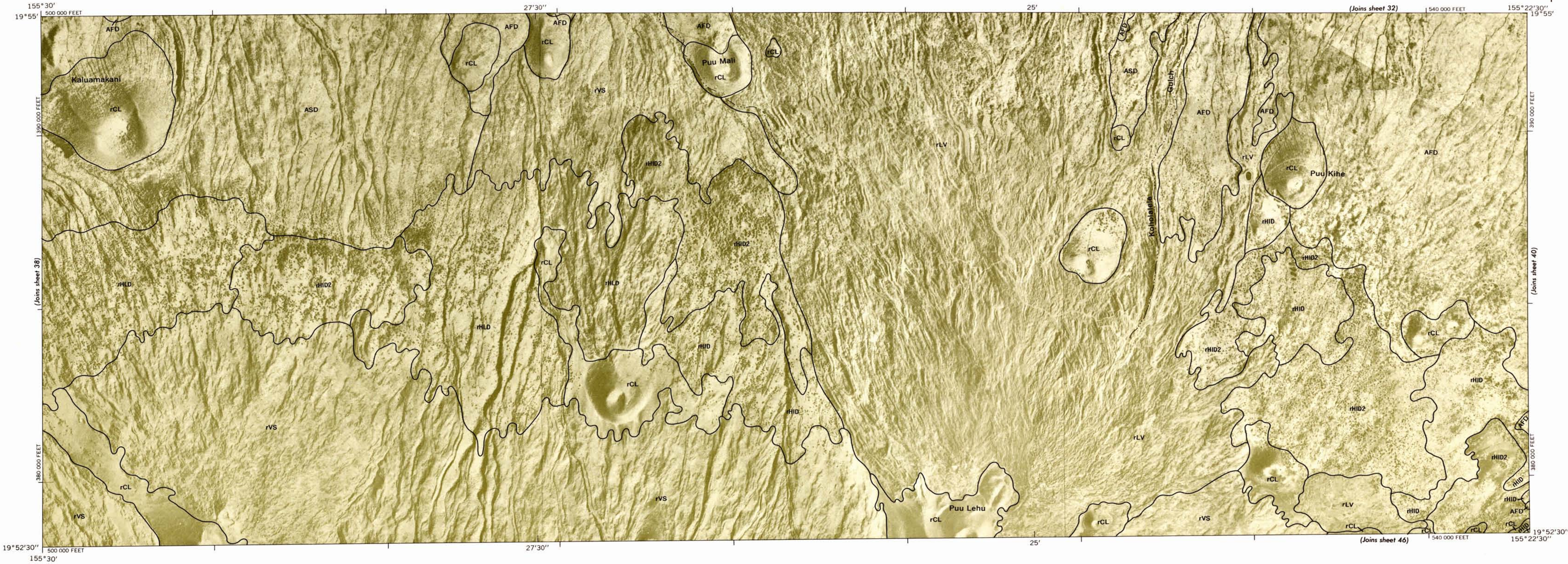
Photobase from 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 1. Old Hawaiian datum.

HAWAII ISLAND, HAWAII NO. 38

This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the University of Hawaii Agricultural Experiment Station

39

N



Photobase from 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 1. Old Hawaiian datum.

Scale 1:24 000

1 ¾ ½ ¼ 0 1 2 Miles

5000 4000 3000 2000 1000 0 5000 10000 Feet

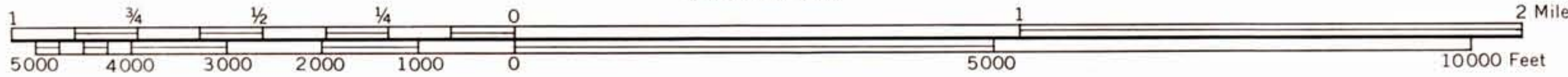
This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the University of Hawaii Agricultural Experiment Station.

HAWAII ISLAND, HAWAII NO. 39

HAWAII ISLAND, HAWAII — SHEET NUMBER 40

N

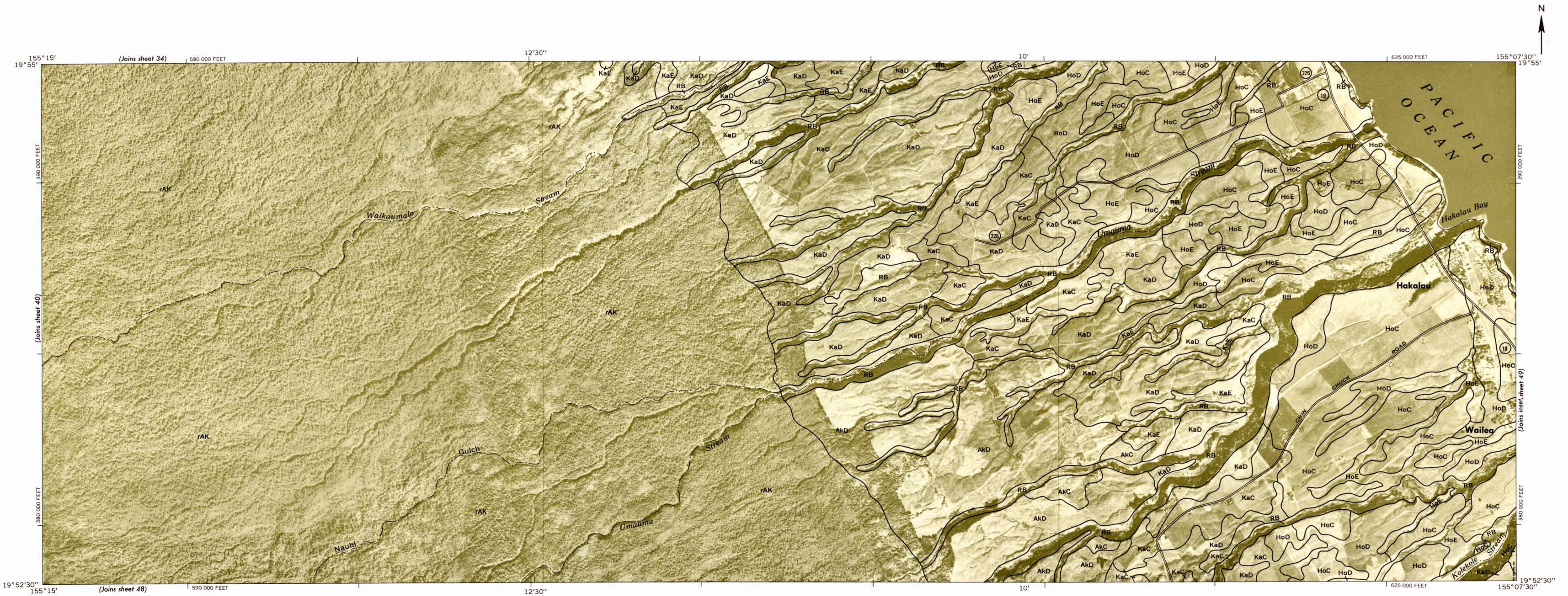
Scale 1:24 000



Photobase from 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 1. Old Hawaiian datum.

HAWAII ISLAND, HAWAII NO. 40

This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the University of Hawaii Agricultural Experiment Station.



HAWAII ISLAND, HAWAII NO. 41

This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the University of Hawaii Agricultural Experiment Station.

Photobase from 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 1. Old Hawaiian datum.

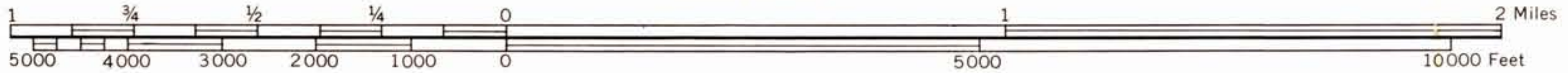
Scale 1:24 000

1 ¾ ½ ¼ 0 1 2 Miles

5000 4000 3000 2000 1000 0 5000 10000 Feet

(42)

Scale 1:24 000



Photobase from 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 1. Old Hawaiian datum.

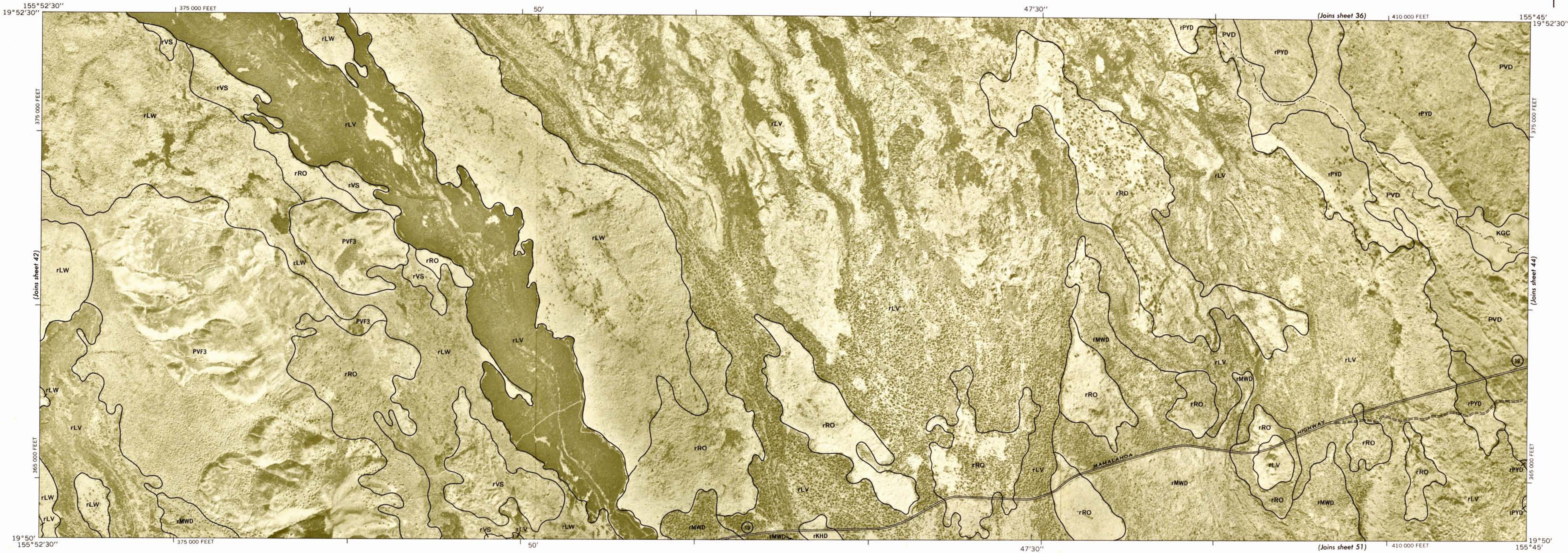
HAWAII ISLAND, HAWAII NO. 42

This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the University of Hawaii Agricultural Experiment Station.

N

This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the University of Hawaii Agricultural Experiment Station.

HAWAII ISLAND, HAWAII NO. 43



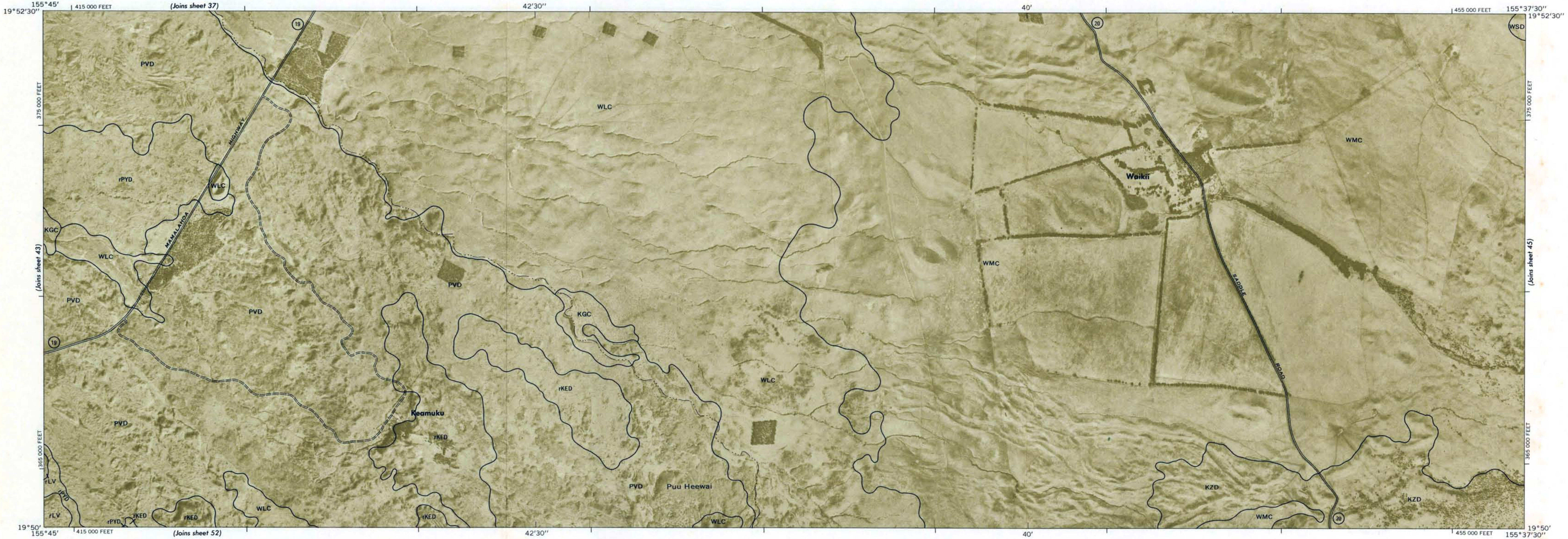
Photobase from 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 1. Old Hawaiian datum.

Scale 1:24 000

1 ¾ ½ ¼ 0 1 2 Miles

5000 4000 3000 2000 1000 0 5000 10000 Feet

HAWAII ISLAND, HAWAII — SHEET NUMBER 44



Scale 1:24 000

1 ¾ ½ ¼ 0 1 2 Miles

5000 4000 3000 2000 1000 0 5000 10000 Feet

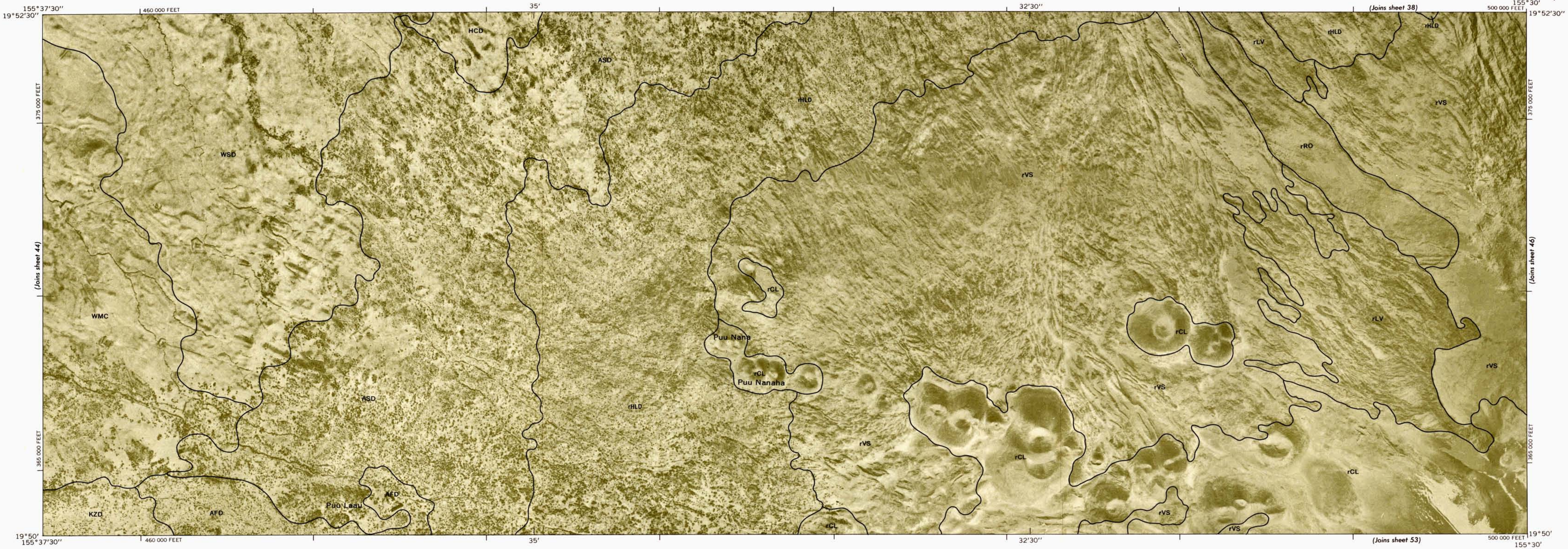
Photobase from 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 1. Old Hawaiian datum.

HAWAII ISLAND, HAWAII NO. 44

This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the University of Hawaii Agricultural Experiment Station.

45

N



Photobase from 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 1. Old Hawaiian datum.

Scale 1:24 000

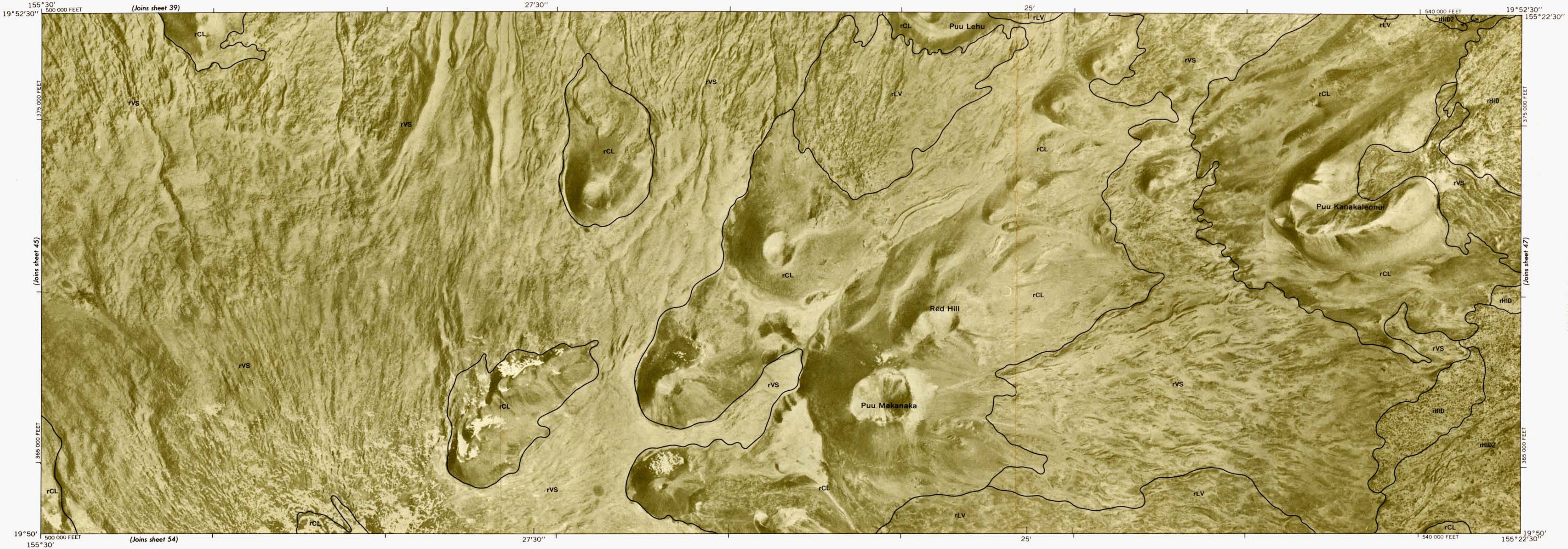
1 ¾ ½ ¼ 0 1 2 Miles

5000 4000 3000 2000 1000 0 5000 10000 Feet

HAWAII ISLAND, HAWAII NO. 45

This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the University of Hawaii Agricultural Experiment Station.

N



Photobase from 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 1. Old Hawaiian datum.

Scale 1:24 000

1 ¾ ½ ¼ 0 1 2 Miles

5000 4000 3000 2000 1000 0 5000 10000 Feet

HAWAII ISLAND, HAWAII NO. 46

This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the University of Hawaii Agricultural Experiment Station.

This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the University of Hawaii Agricultural Experiment Station.

HAWAII ISLAND, HAWAII NO. 47

Photobase from 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 1. Old Hawaiian datum.

Scale 1:24 000

1 ¾ ½ ¼ 0 1 2 Miles

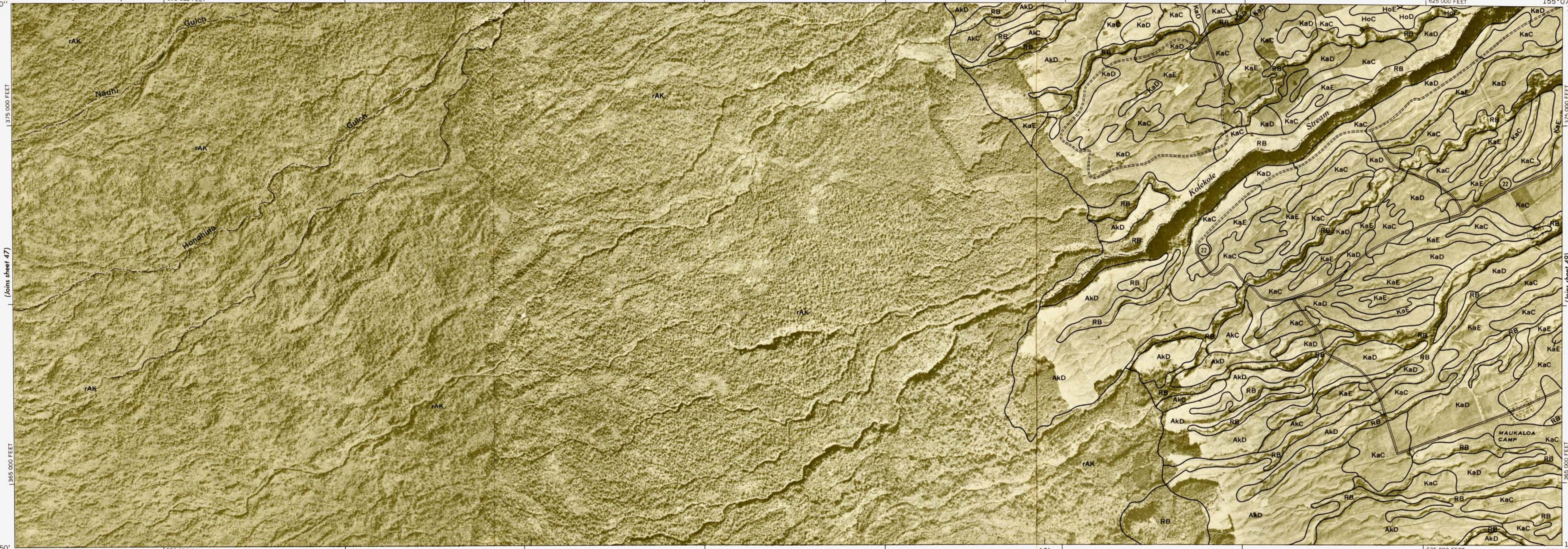
5000 4000 3000 2000 1000 0 5000 10000 Feet

N

155°15′ (Joins sheet 41) 590 000 FEET 12′30″ 10′ 625 000 FEET 155°07′30″

19°52′30″ 19°52′30″

375 000 FEET (Joins sheet 47) 365 000 FEET



375 000 FEET (Joins sheet 49) 365 000 FEET

19°50′ 19°50′

155°15′ (Joins sheet 56) 590 000 FEET 12′30″ 10′ 625 000 FEET 155°07′30″

Photobase from 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 1. Old Hawaiian datum.

Scale 1:24 000

1 ¾ ½ ¼ 0 1 2 Miles

5000 4000 3000 2000 1000 0 5000 10000 Feet

HAWAII ISLAND, HAWAII NO. 48

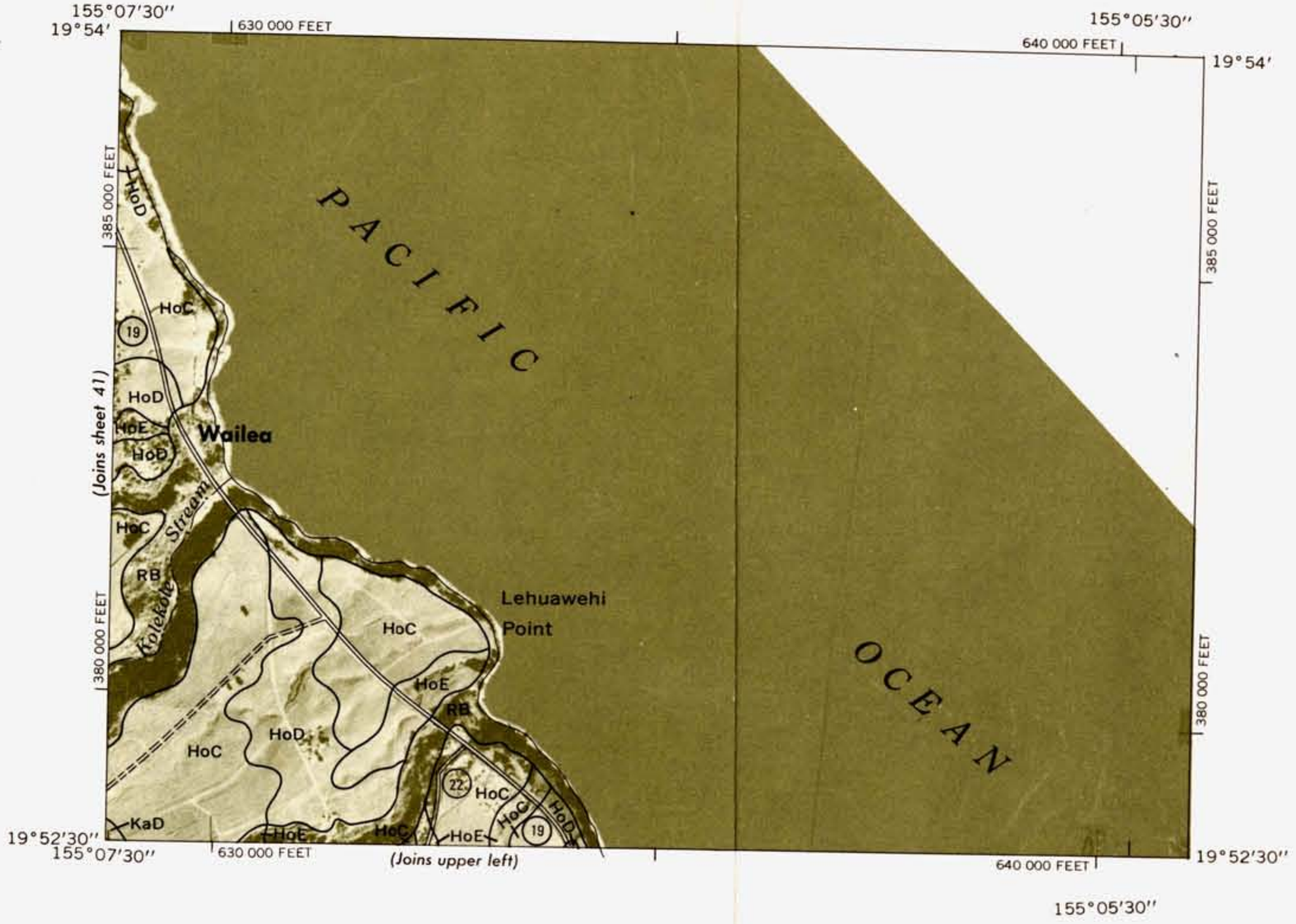
This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the University of Hawaii Agricultural Experiment Station.

49

N

This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the University of Hawaii Agricultural Experiment Station.

HAWAII ISLAND, HAWAII NO. 49



Photobase from 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 1. Old Hawaiian datum.

Scale 1:24 000

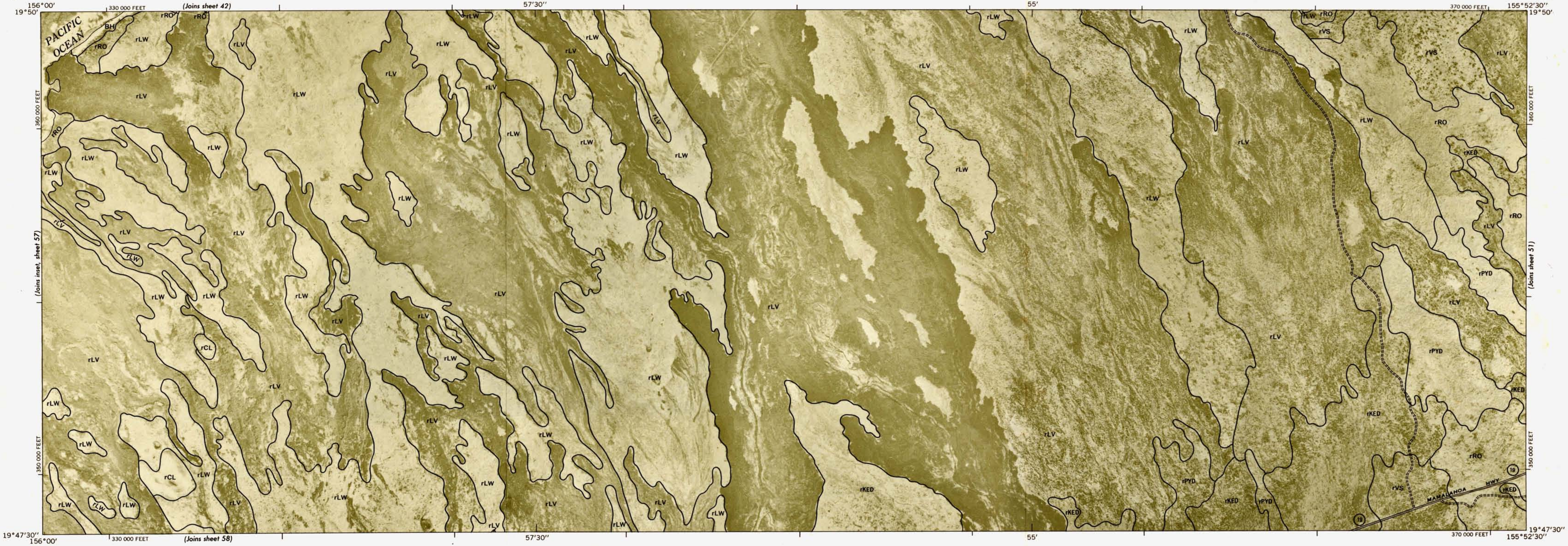
1 ¾ ½ ¼ 0 1 2 Miles

5000 4000 3000 2000 1000 0 5000 10000 Feet

(50)

HAWAII ISLAND, HAWAII — SHEET NUMBER 50

N



Scale 1:24 000

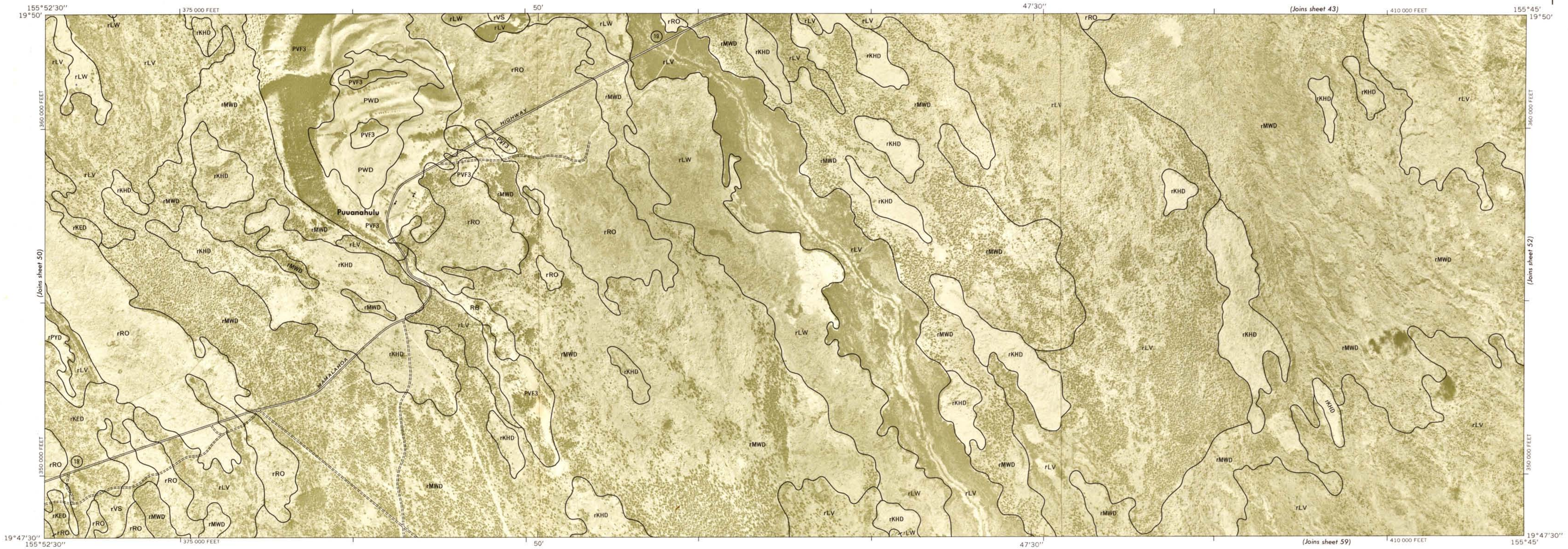
1 ¾ ½ ¼ 0 1 2 Miles

5000 4000 3000 2000 1000 0 5000 10000 Feet

Photobase from 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 1. Old Hawaiian datum.

HAWAII ISLAND, HAWAII NO. 50

This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the University of Hawaii Agricultural Experiment Station.



Photobase from 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 1. Old Hawaiian datum.

Scale 1:24 000

1 ¾ ½ ¼ 0 1 2 Miles

5000 4000 3000 2000 1000 0 5000 10000 Feet

This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the University of Hawaii Agricultural Experiment Station.

Scale 1:24 000

1 ¾ ½ ¼ 0 1 2 Miles

5000 4000 3000 2000 1000 0 5000 10000 Feet

Photobase from 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 1, Old Hawaiian datum.

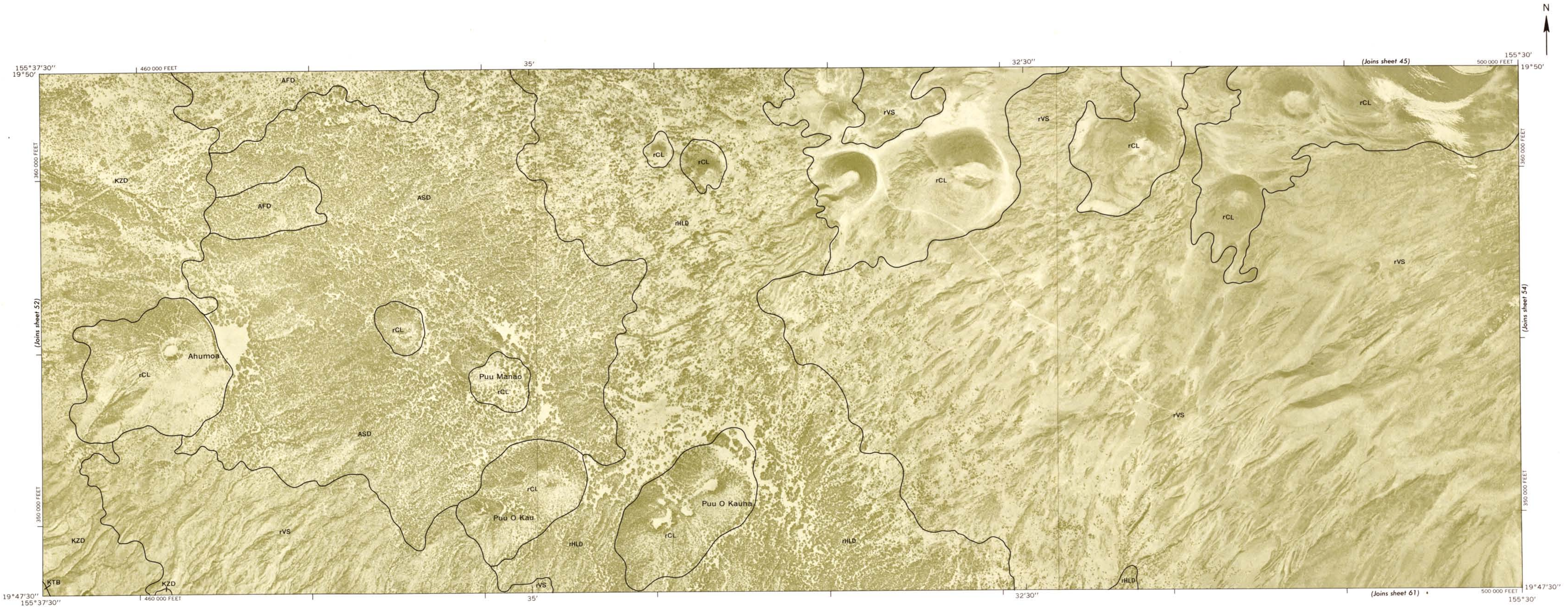
HAWAII ISLAND, HAWAII NO. 52

This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the University of Hawaii Agricultural Experiment Station.

53

This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the University of Hawaii Agricultural Experiment Station.

HAWAII ISLAND, HAWAII NO. 53



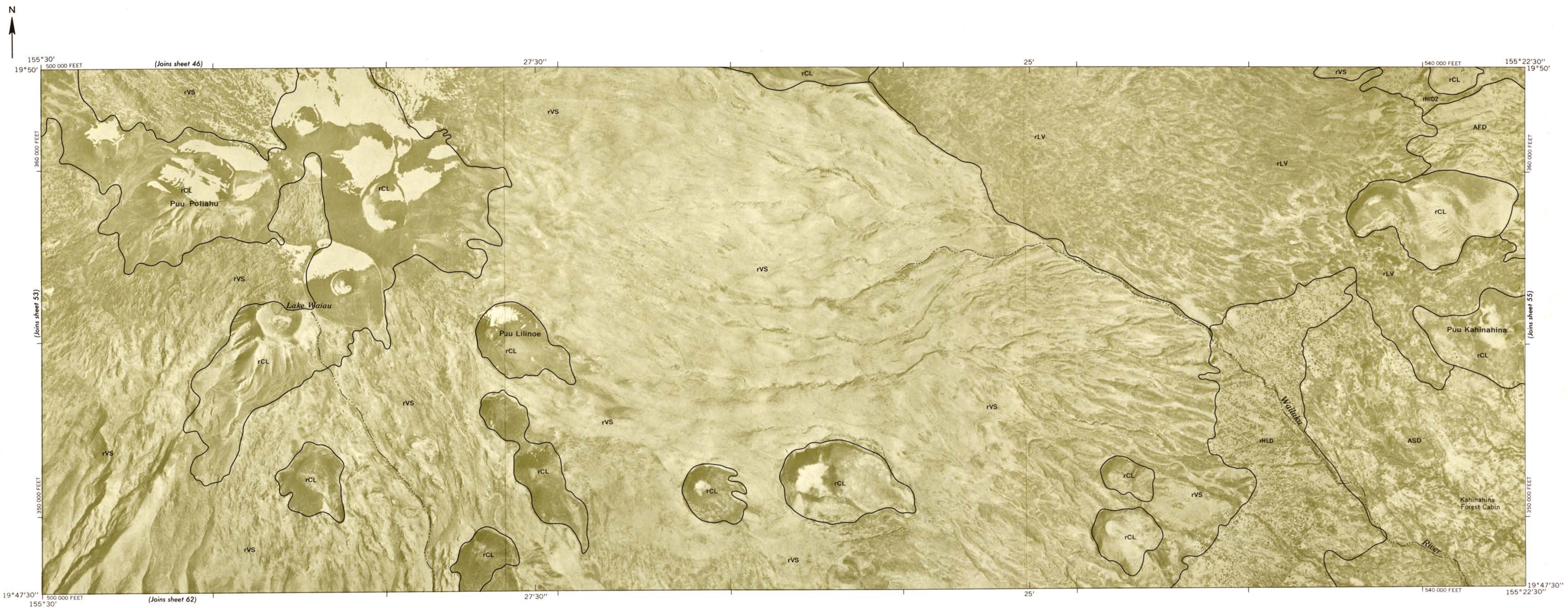
Photobase from 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 1. Old Hawaiian datum.

Scale 1:24 000

1 ¾ ½ ¼ 0 1 2 Miles

5000 4000 3000 2000 1000 0 5000 10000 Feet

HAWAII ISLAND, HAWAII — SHEET NUMBER 54

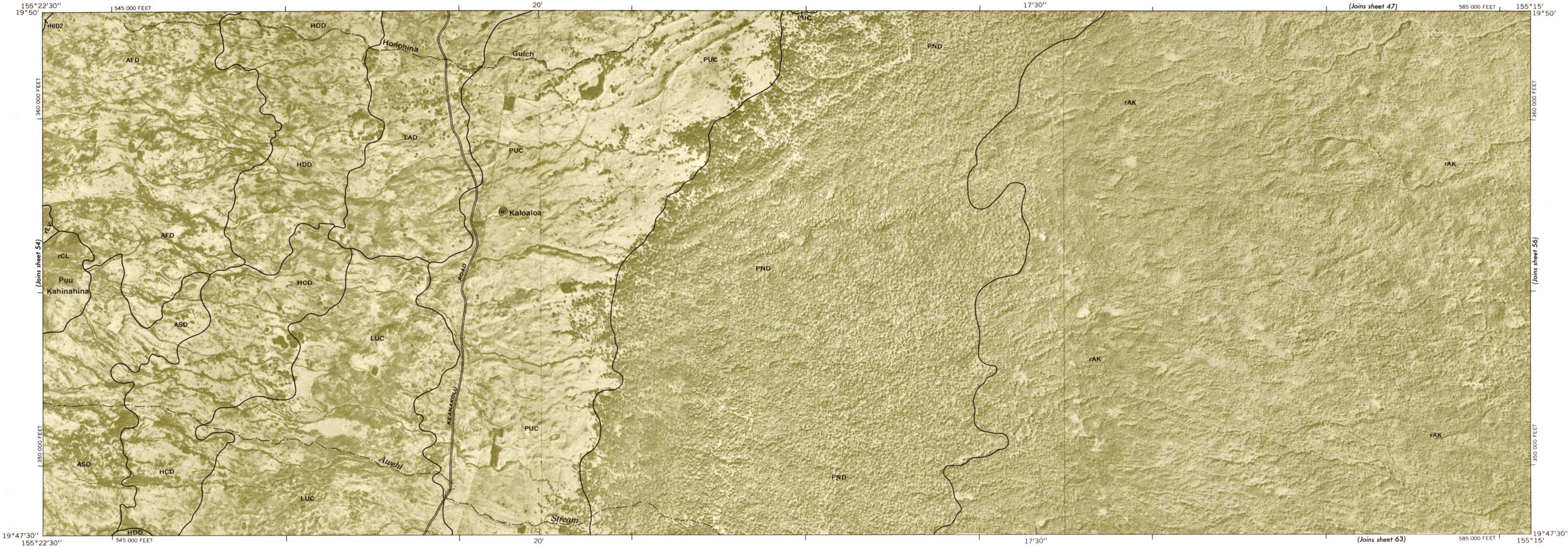


Scale 1:24 000

Photobase from 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 1. Old Hawaiian datum.

HAWAII ISLAND, HAWAII NO. 54

This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the University of Hawaii Agricultural Experiment Station.



This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the University of Hawaii Agricultural Experiment Station.

Photobase from 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 1. Old Hawaiian datum.

Scale 1:24 000

1 ¾ ½ ¼ 0 1 2 Miles

5000 4000 3000 2000 1000 0 5000 10000 Feet

HAWAII ISLAND, HAWAII — SHEET NUMBER 56

N

Scale 1:24 000

1 ¾ ½ ¼ 0 1 2 Miles

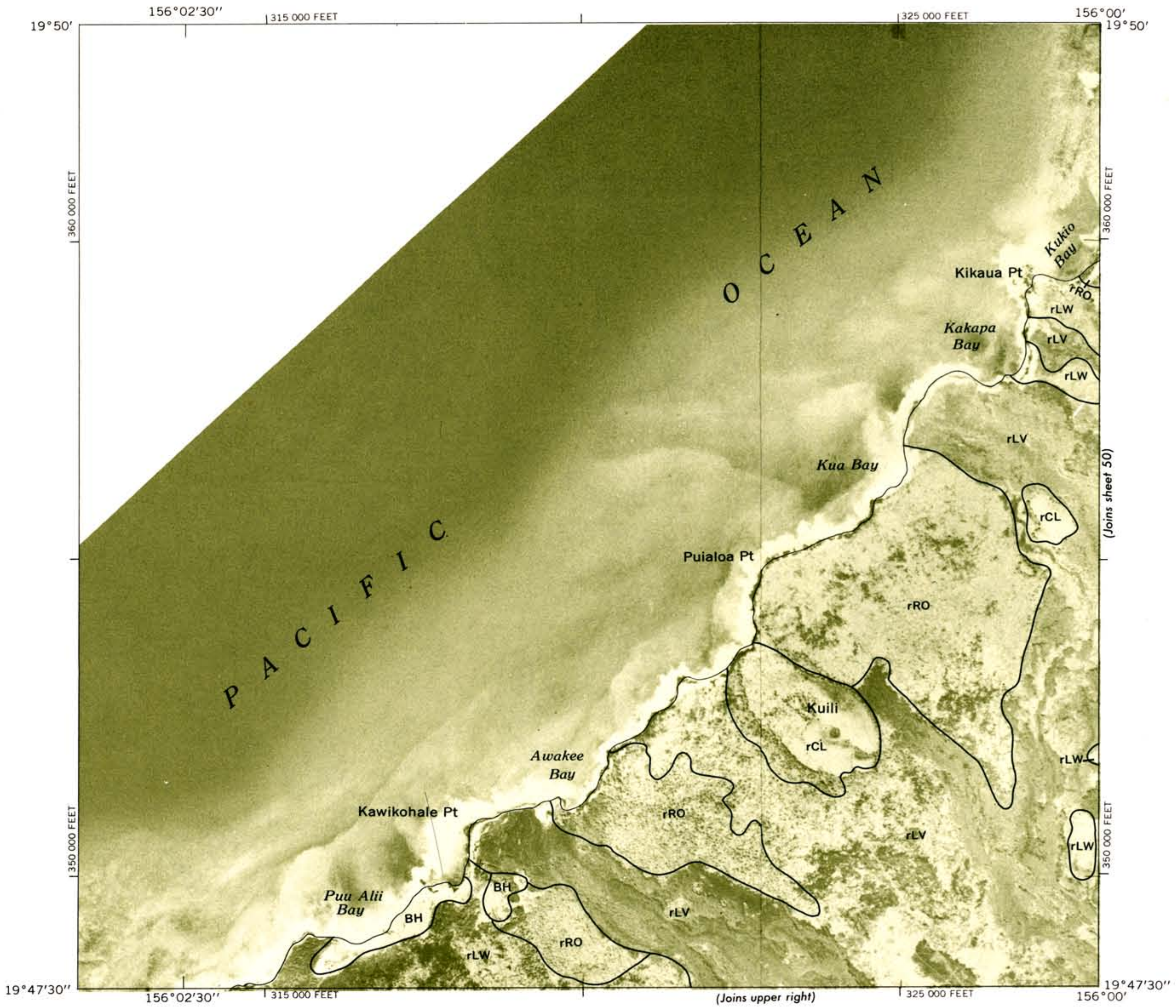
5000 4000 3000 2000 1000 0 5000 10000 Feet

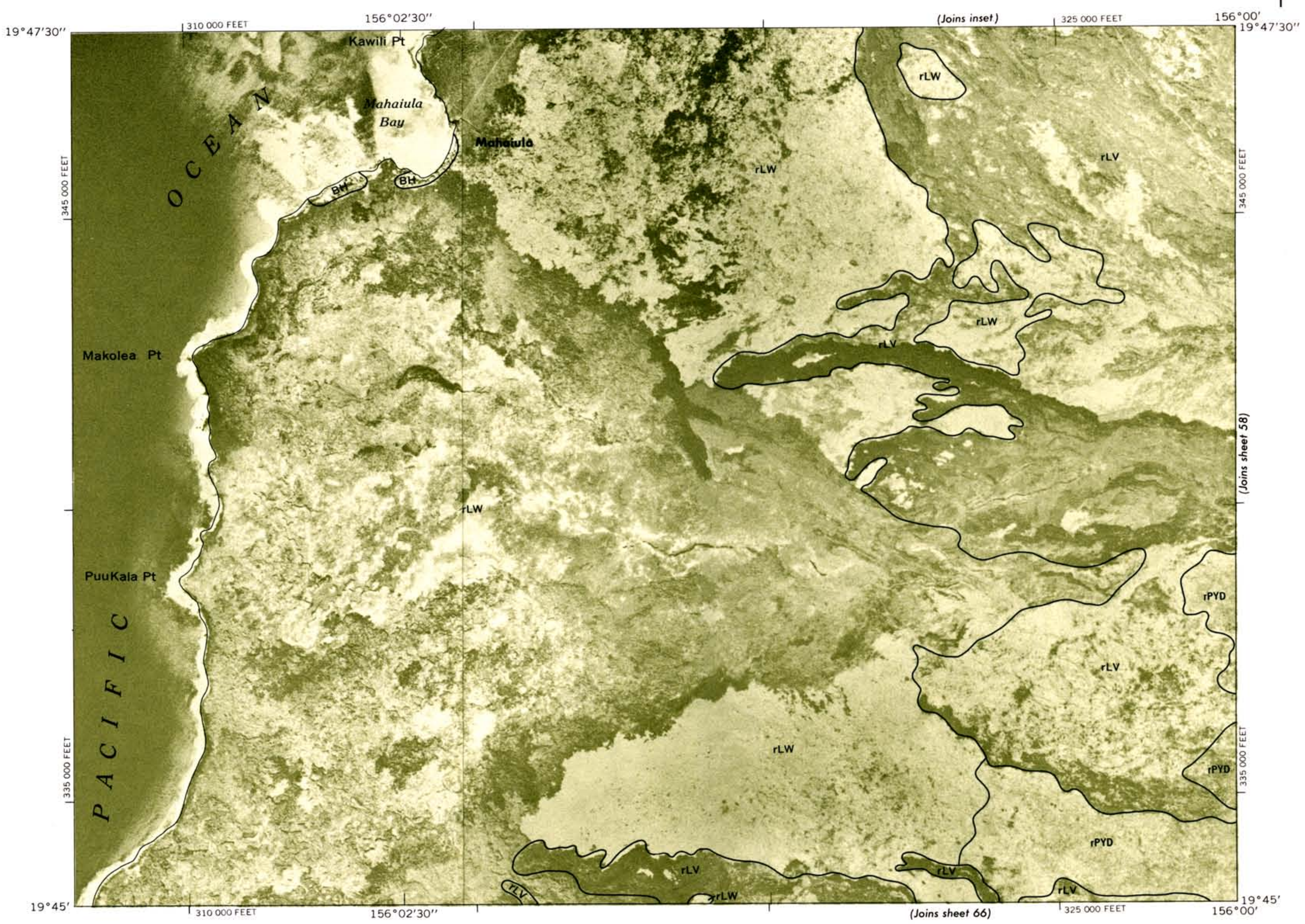
Photobase from 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 1. Old Hawaiian datum.

HAWAII ISLAND, HAWAII NO. 56

This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the University of Hawaii Agricultural Experiment Station.

N





Photobase from 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 1. Old Hawaiian datum.

Scale 1:24 000

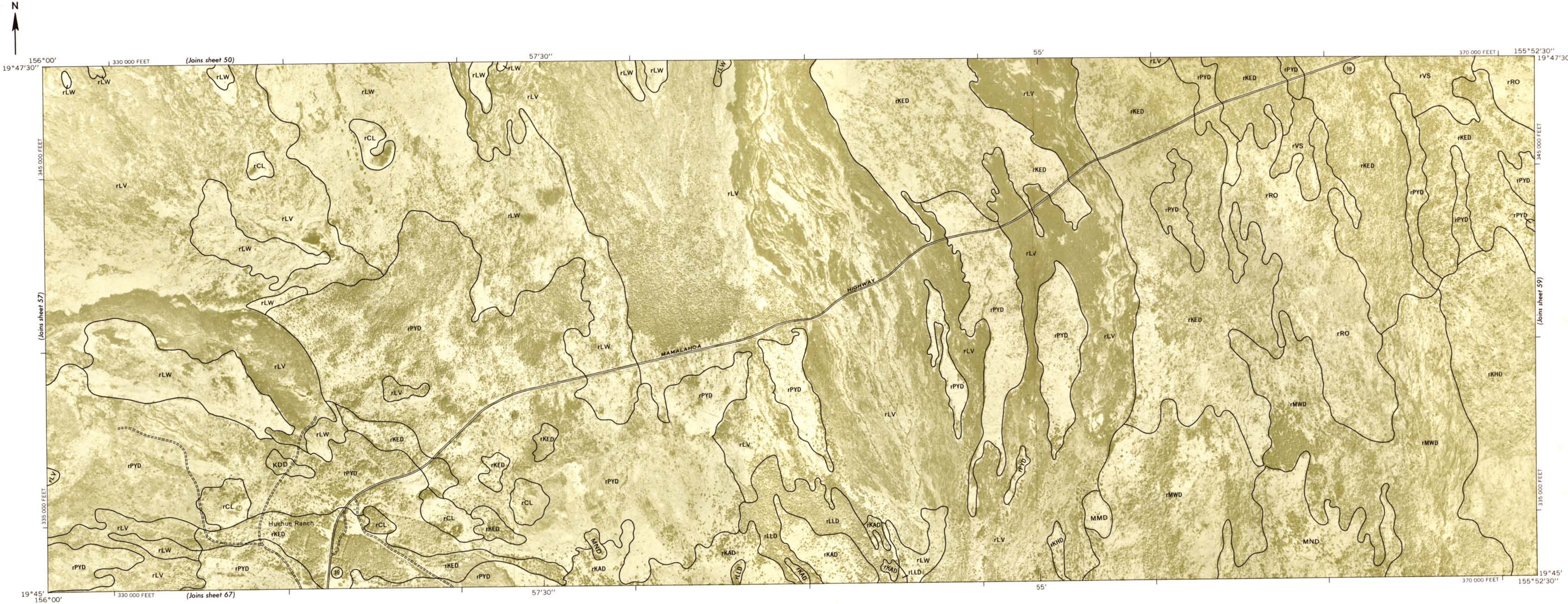
1 ¾ ½ ¼ 0 1 2 Miles

5000 4000 3000 2000 1000 0 5000 10000 Feet

HAWAII ISLAND, HAWAII NO. 57

This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the University of Hawaii Agricultural Experiment Station.

58



Scale 1:24 000

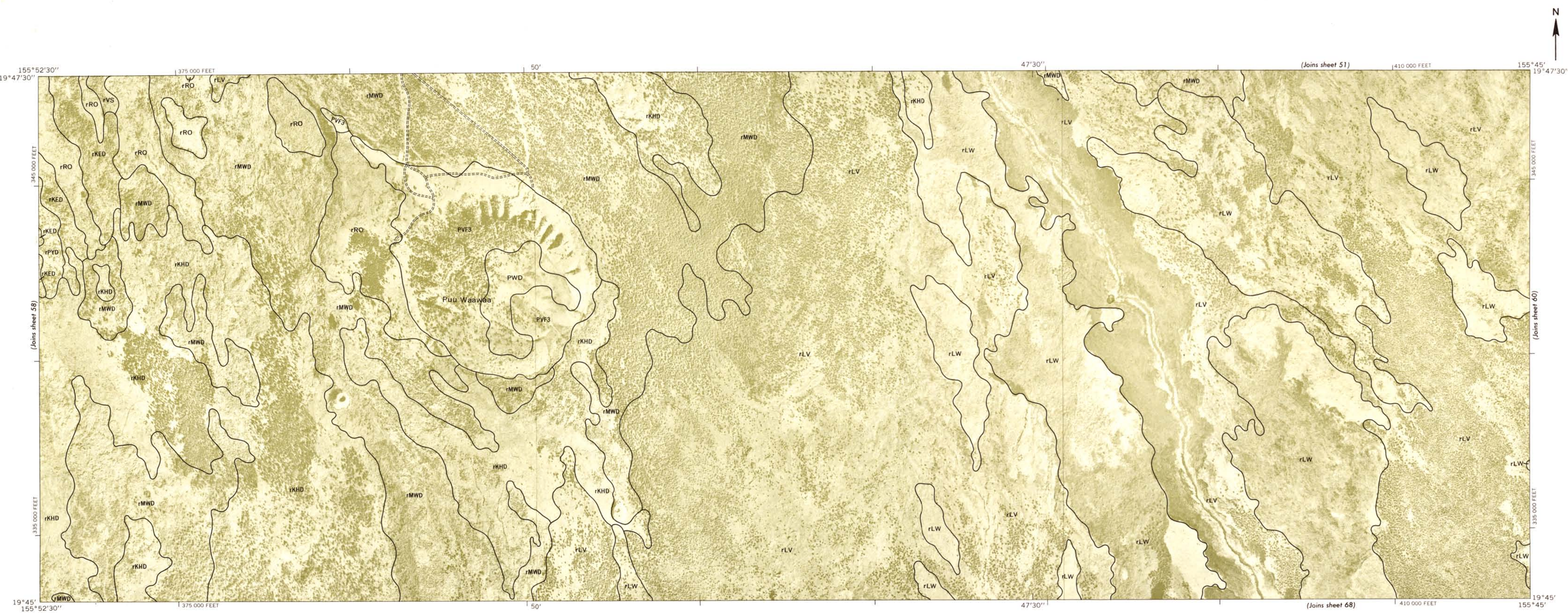
Photobase from 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 1. Old Hawaiian datum.

HAWAII ISLAND, HAWAII NO. 58

This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the University of Hawaii Agricultural Experiment Station.

This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the University of Hawaii Agricultural Experiment Station.

HAWAII ISLAND, HAWAII NO. 59

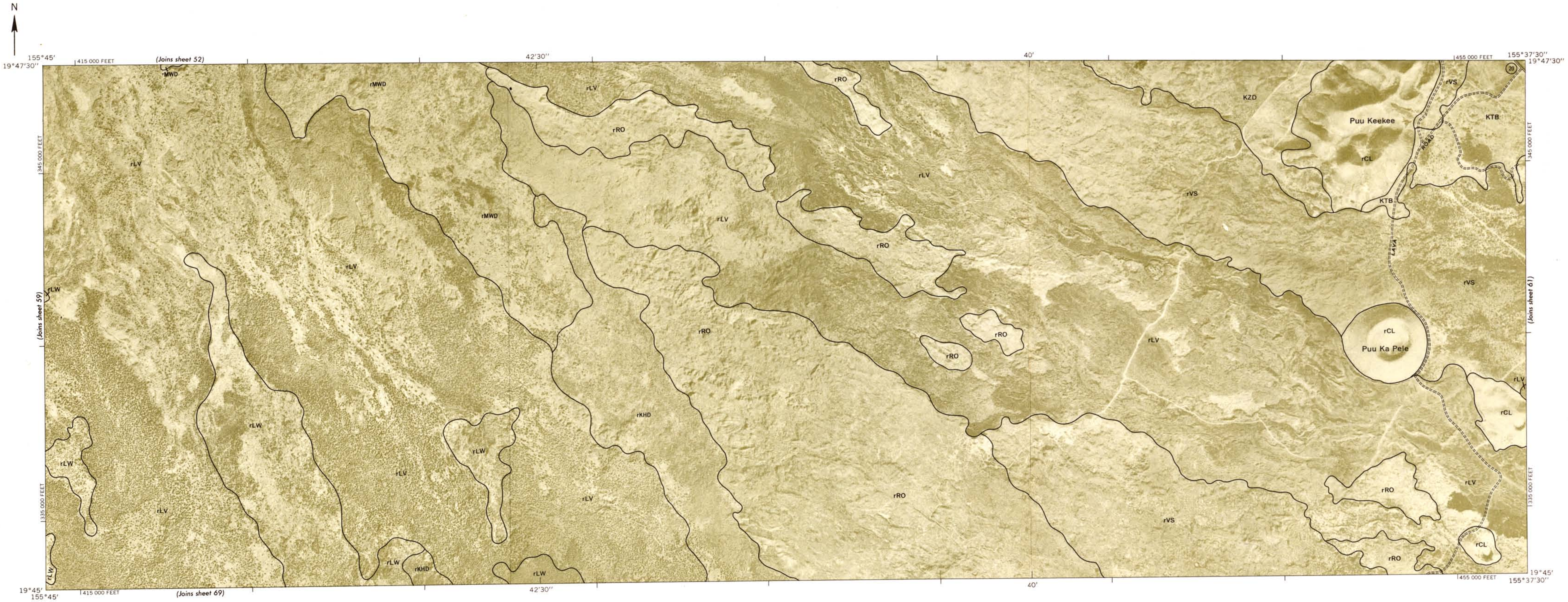


Photobase from 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 1. Old Hawaiian datum.

Scale 1:24 000

1 ¾ ½ ¼ 0 1 2 Miles

5000 4000 3000 2000 1000 0 5000 10000 Feet



Photobase from 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 1. Old Hawaiian datum.

Scale 1:24 000

1 ¾ ½ ¼ 0 1 2 Miles

5000 4000 3000 2000 1000 0 5000 10000 Feet

HAWAII ISLAND, HAWAII NO. 60

This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the University of Hawaii Agricultural Experiment Station.

N

HAWAII ISLAND, HAWAII NO. 61

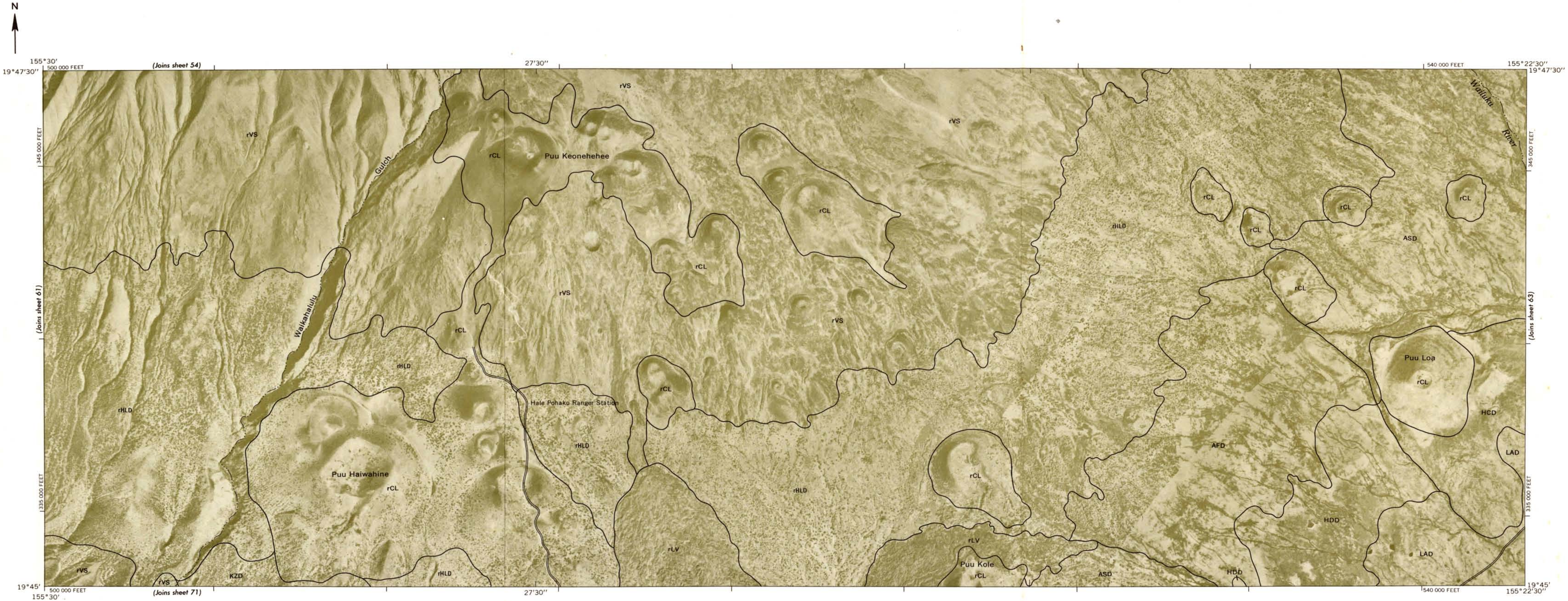
This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the University of Hawaii Agricultural Experiment Station.

Photobase from 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 1. Old Hawaiian datum.

Scale 1:24 000

1 ¾ ½ ¼ 0 1 2 Miles

5000 4000 3000 2000 1000 0 5000 10000 Feet

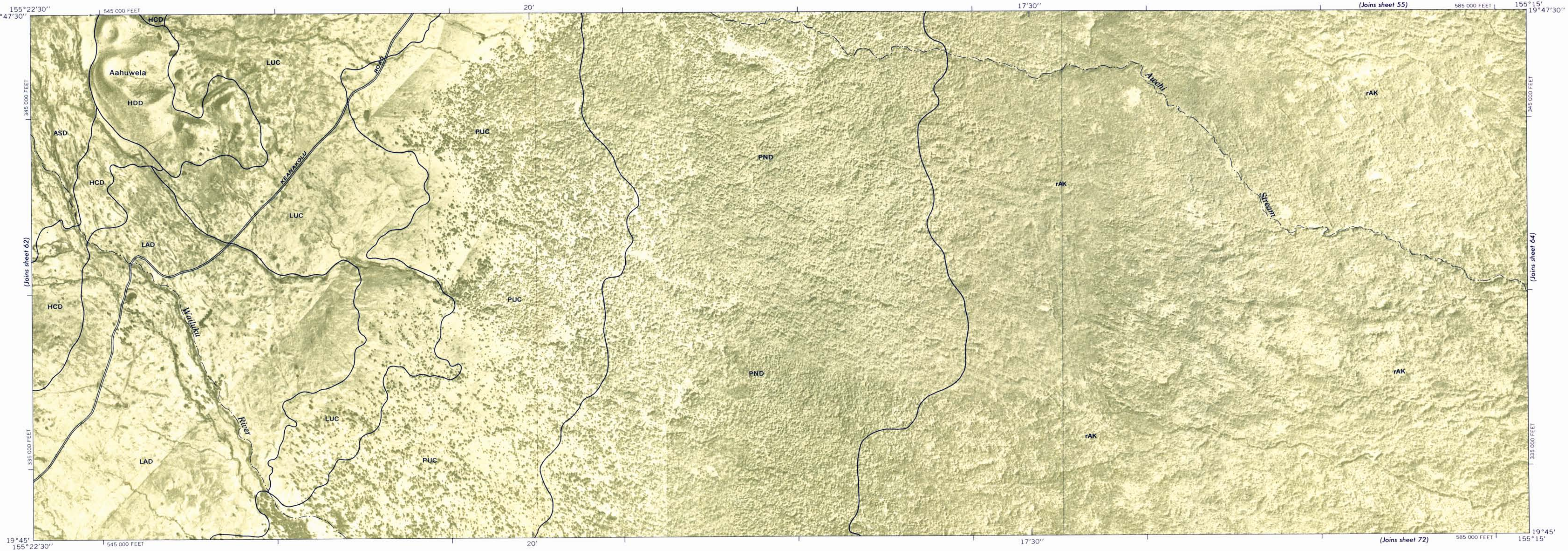


Scale 1:24 000

1 ¾ ½ ¼ 0 1 2 Miles

5000 4000 3000 2000 1000 0 5000 10000 Feet

Photobase from 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 1. Old Hawaiian datum.



HAWAII ISLAND, HAWAII NO. 63

This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the University of Hawaii Agricultural Experiment Station.

Photobase from 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 1. Old Hawaiian datum.

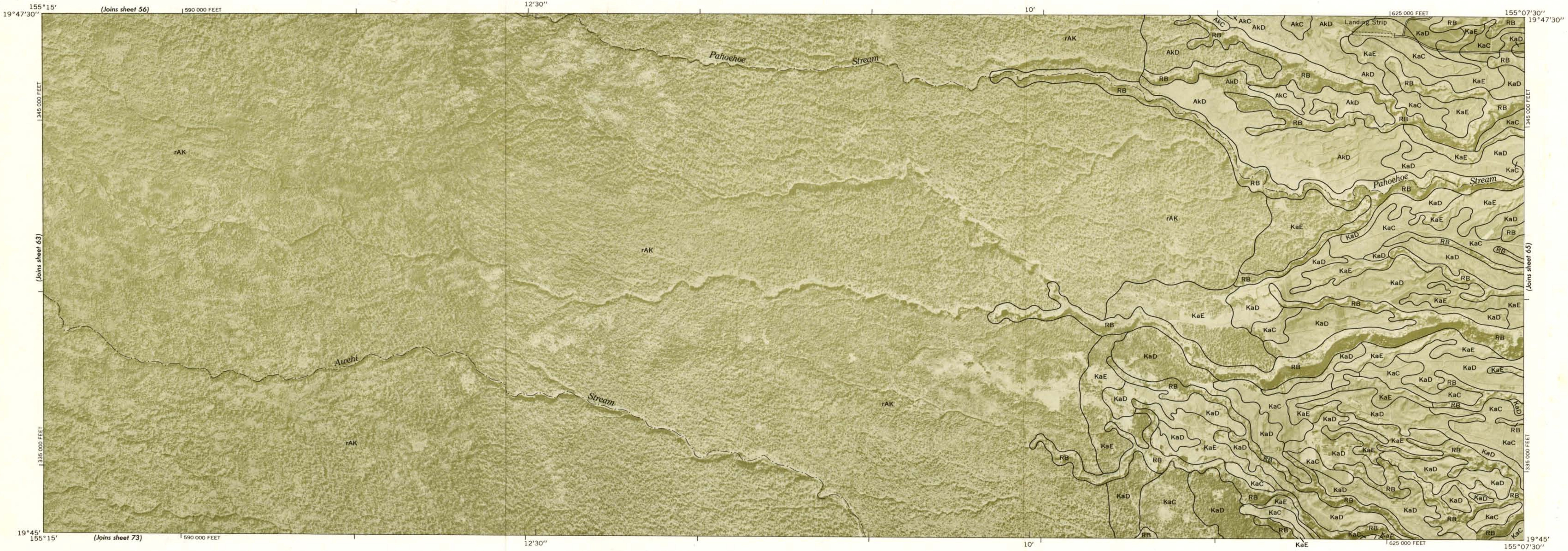
Scale 1:24 000

1 ¾ ½ ¼ 0 1 2 Miles

5000 4000 3000 2000 1000 0 5000 10000 Feet

64

N



Scale 1:24 000

1 ¾ ½ ¼ 0 1 2 Miles

5000 4000 3000 2000 1000 0 5000 10000 Feet

Photobase from 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 1. Old Hawaiian datum.

HAWAII ISLAND, HAWAII NO. 64

This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the University of Hawaii Agricultural Experiment Station.

N

Photobase from 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 1. Old Hawaiian datum.

Scale 1:24 000

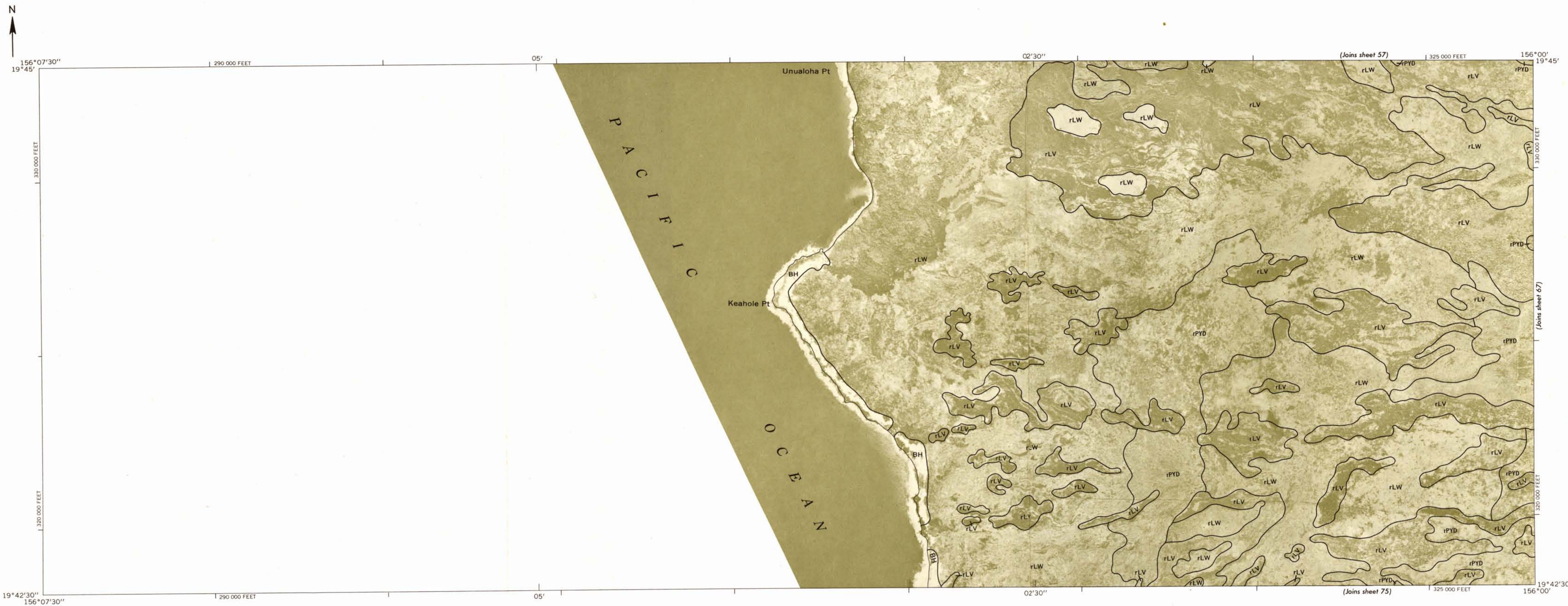
1 ¾ ½ ¼ 0 1 2 Miles

5000 4000 3000 2000 1000 0 5000 10000 Feet

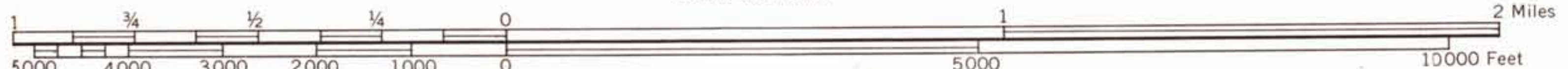
This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the University of Hawaii Agricultural Experiment Station.

HAWAII ISLAND, HAWAII NO. 65

HAWAII ISLAND, HAWAII — SHEET NUMBER 66



Scale 1:24 000

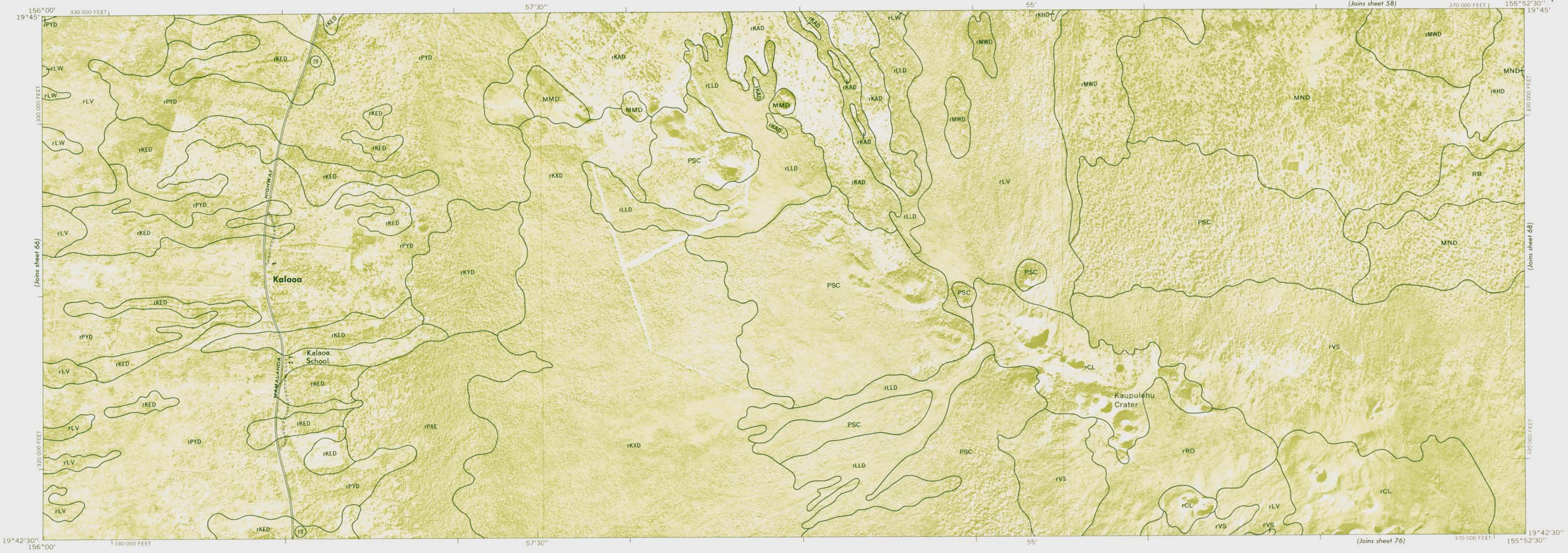


Photobase from 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 1. Old Hawaiian datum.

HAWAII ISLAND, HAWAII NO. 66

This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the University of Hawaii Agricultural Experiment Station.

67



Photobase from 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 1. Old Hawaiian datum.

Scale 1:24 000

1 ¾ ½ ¼ 0 1 2 Miles

5000 4000 3000 2000 1000 0 5000 10000 Feet

HAWAII ISLAND, HAWAII NO. 67

This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the University of Hawaii Agricultural Experiment Station.

HAWAII ISLAND, HAWAII — SHEET NUMBER 68

Scale 1:24 000

1 ¾ ½ ¼ 0 1 2 Miles

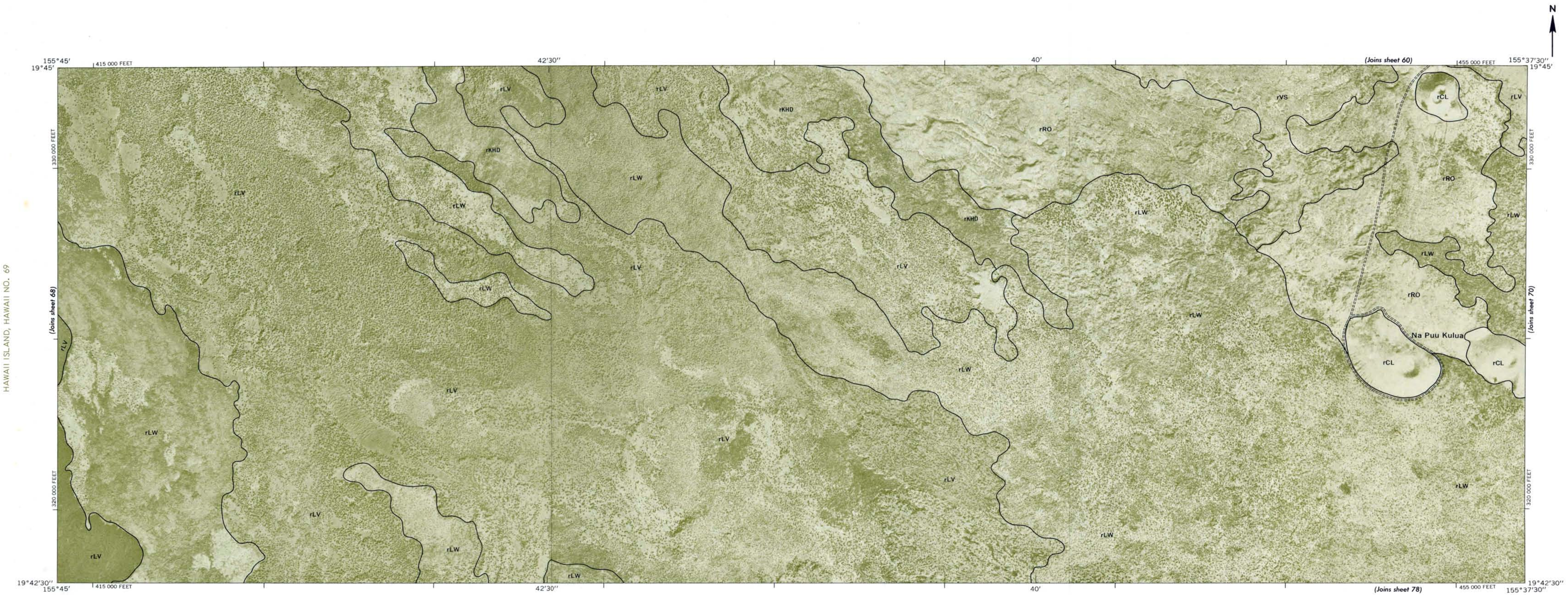
5000 4000 3000 2000 1000 0 5000 10000 Feet

Photobase from 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 1. Old Hawaiian datum.

HAWAII ISLAND, HAWAII NO. 68

This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the University of Hawaii Agricultural Experiment Station.

69



This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the University of Hawaii Agricultural Experiment Station.

HAWAII ISLAND, HAWAII NO. 69

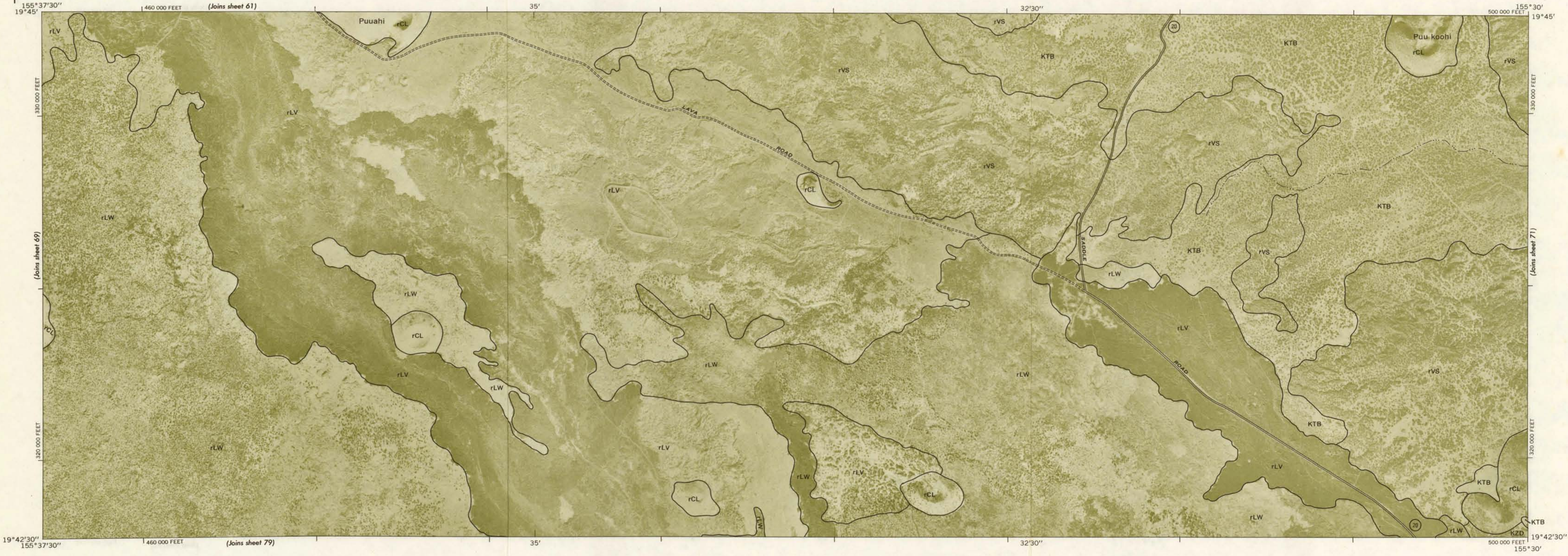
Photobase from 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 1. Old Hawaiian datum.

Scale 1:24 000

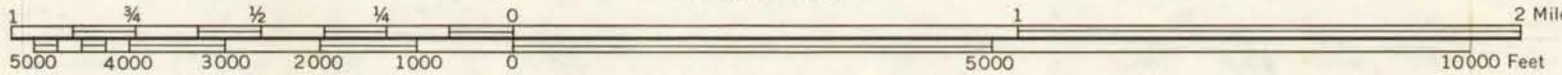
1 ¾ ½ ¼ 0 1 2 Miles

5000 4000 3000 2000 1000 0 5000 10000 Feet

HAWAII ISLAND, HAWAII — SHEET NUMBER 70

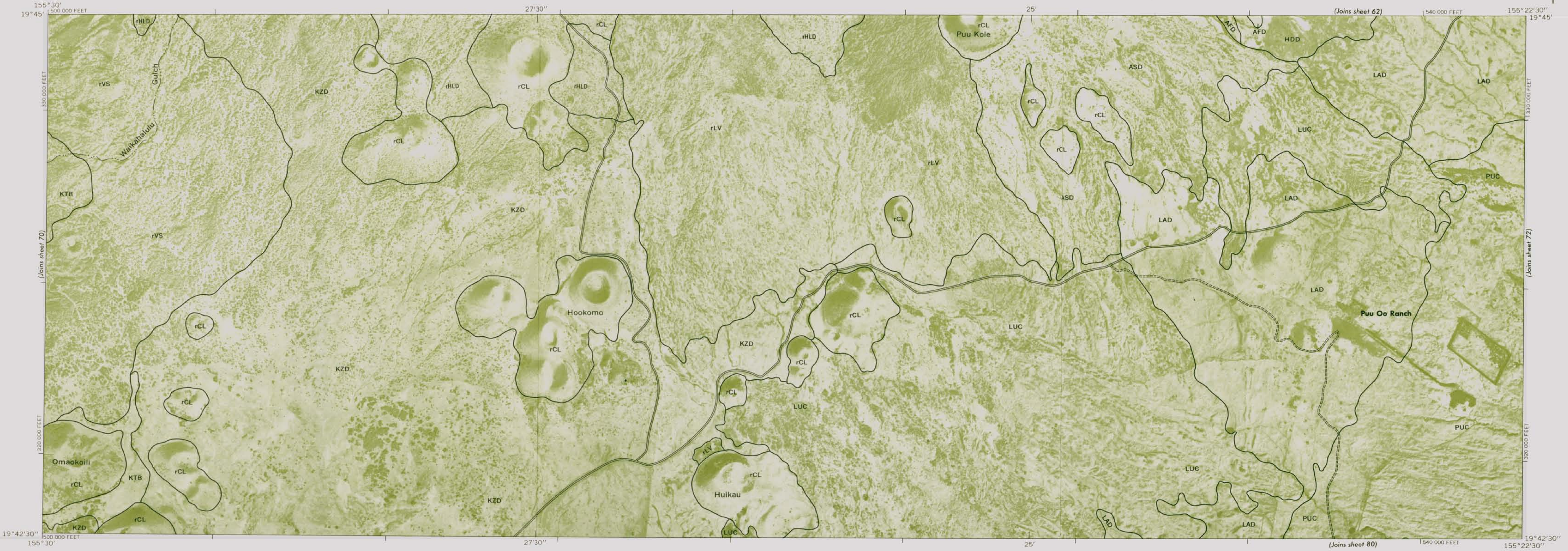


Scale 1:24 000



Photobase from 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 1. Old Hawaiian datum.

This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the University of Hawaii Agricultural Experiment Station.



Photobase from 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 1. Old Hawaiian datum.

Scale 1:24 000

1 ¾ ½ ¼ 0 1 2 Miles

5000 4000 3000 2000 1000 0 5000 10000 Feet

This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the University of Hawaii Agricultural Experiment Station.

HAWAII ISLAND, HAWAII NO. 71

Scale 1:24 000

1 ¾ ½ ¼ 0 1 2 Miles

5000 4000 3000 2000 1000 0 5000 10000 Feet

Photobase from 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 1. Old Hawaiian datum.

HAWAII ISLAND, HAWAII NO. 72

This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the University of Hawaii Agricultural Experiment Station.

N

This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the University of Hawaii Agricultural Experiment Station

HAWAII ISLAND, HAWAII NO. 73

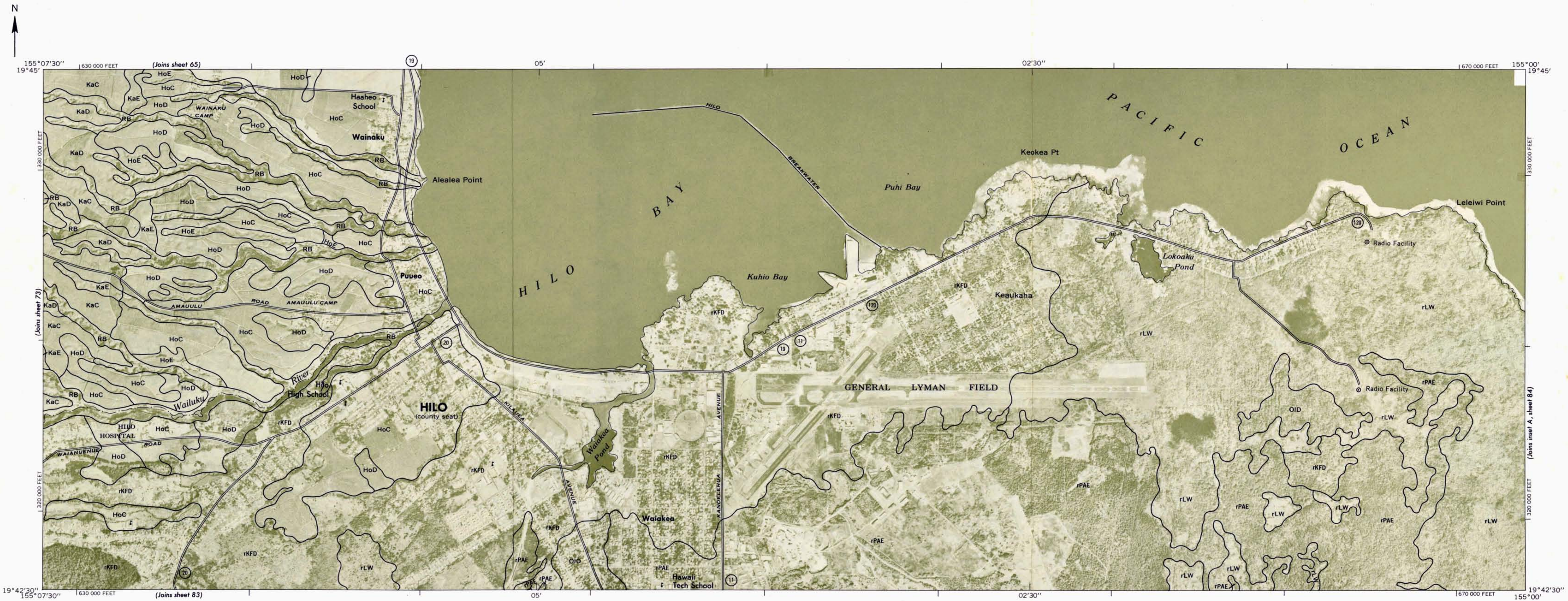
Photobase from 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 1. Old Hawaiian datum.

Scale 1:24 000

1 ¾ ½ ¼ 0 1 2 Miles

5000 4000 3000 2000 1000 0 5000 10000 Feet

HAWAII ISLAND, HAWAII — SHEET NUMBER 74



Scale 1:24 000

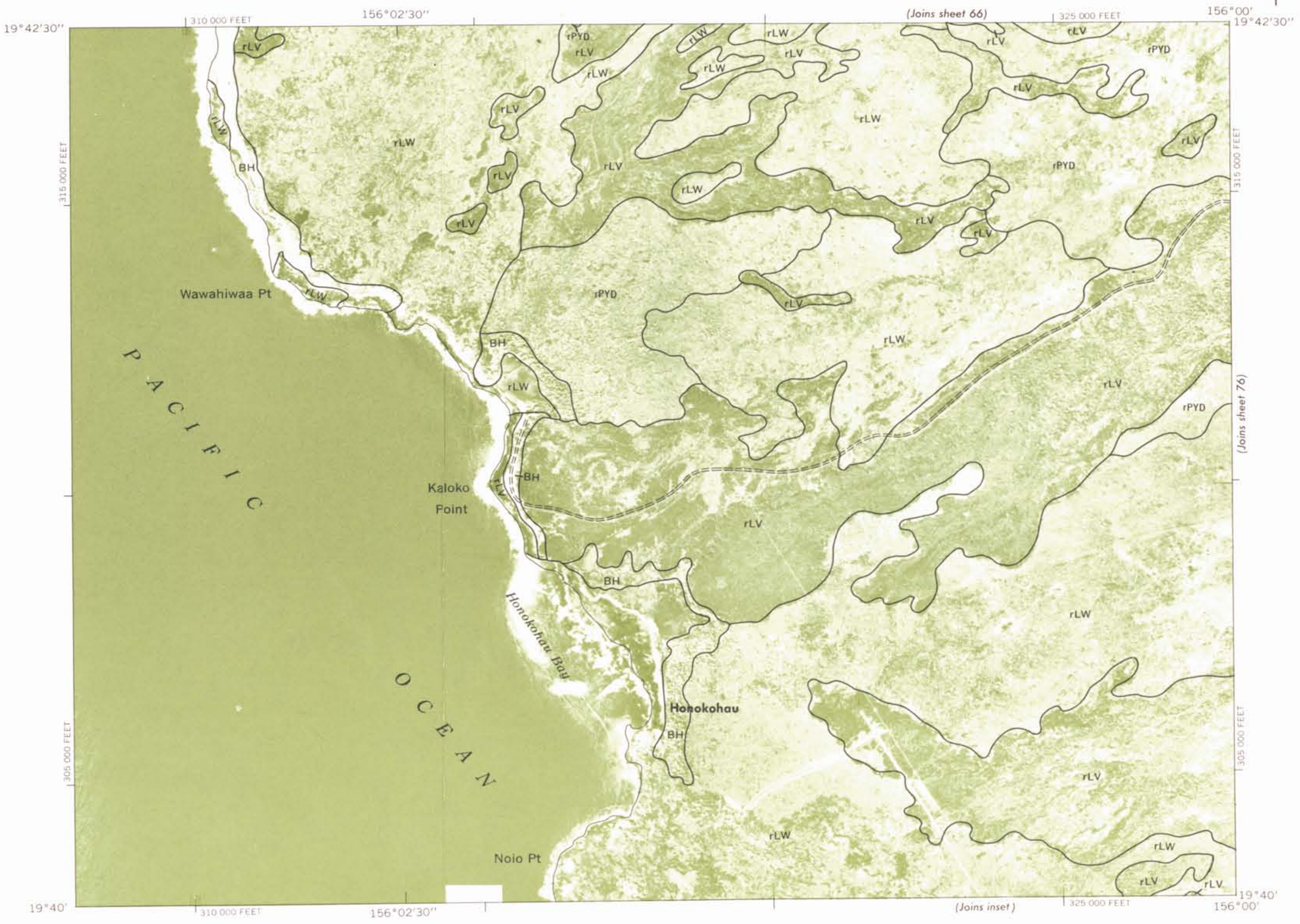
1 ¾ ½ ¼ 0 1 2 Miles

5000 4000 3000 2000 1000 0 5000 10000 Feet

Photobase from 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 1. Old Hawaiian datum.

HAWAII ISLAND, HAWAII NO. 74

This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the University of Hawaii Agricultural Experiment Station.



Photobase from 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 1. Old Hawaiian datum

Scale 1:24 000

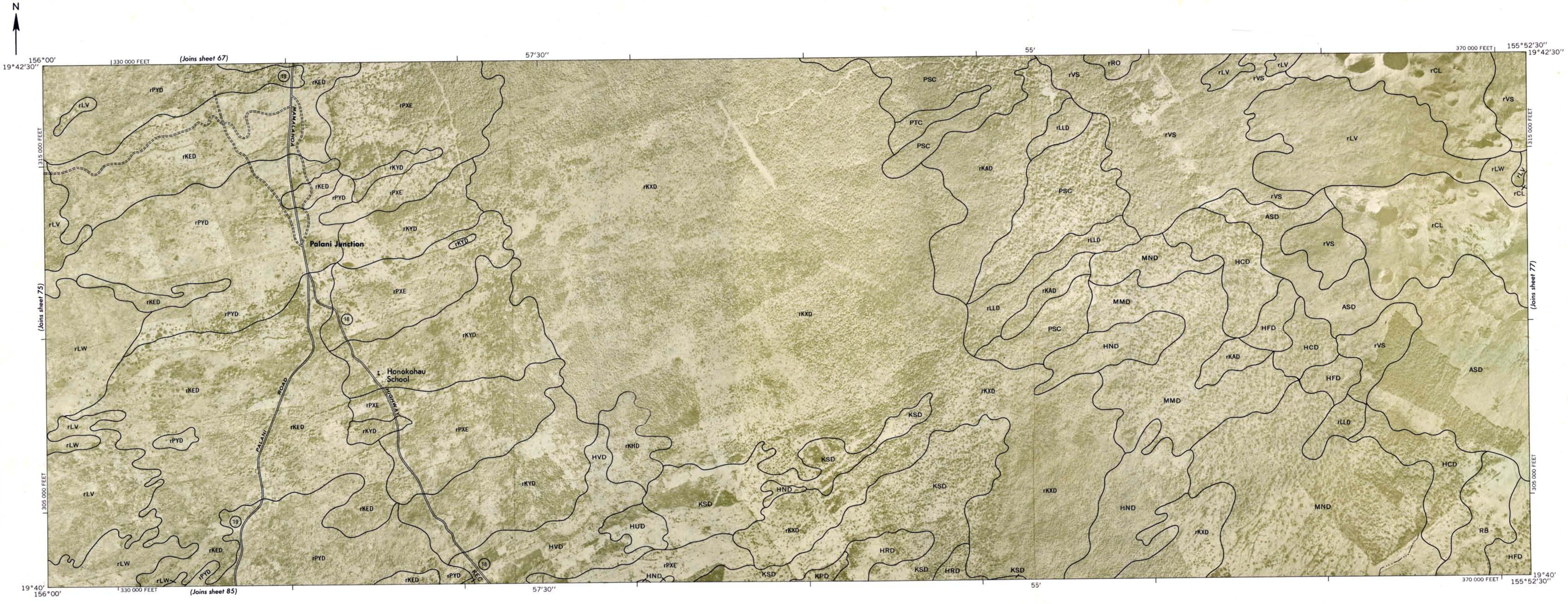
1 ¾ ½ ¼ 0 1 2 Miles

5000 4000 3000 2000 1000 0 5000 10000 Feet

This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the University of Hawaii Agricultural Experiment Station.

HAWAII ISLAND, HAWAII NO. 75

HAWAII ISLAND, HAWAII — SHEET NUMBER 76



Scale 1:24 000

1 ¾ ½ ¼ 0 1 2 Miles

5000 4000 3000 2000 1000 0 5000 10000 Feet

Photobase from 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 1. Old Hawaiian datum.

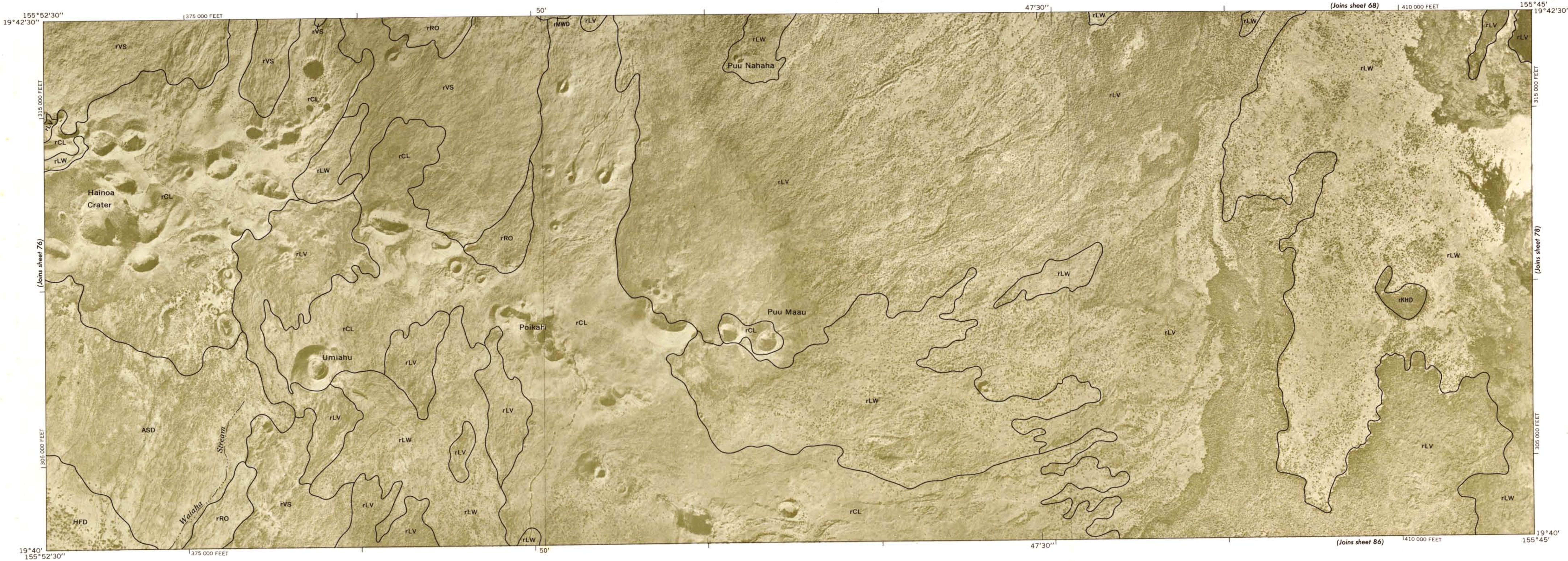
HAWAII ISLAND, HAWAII NO. 76

This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the University of Hawaii Agricultural Experiment Station.

N

This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the University of Hawaii Agricultural Experiment Station.

HAWAII ISLAND, HAWAII NO. 77

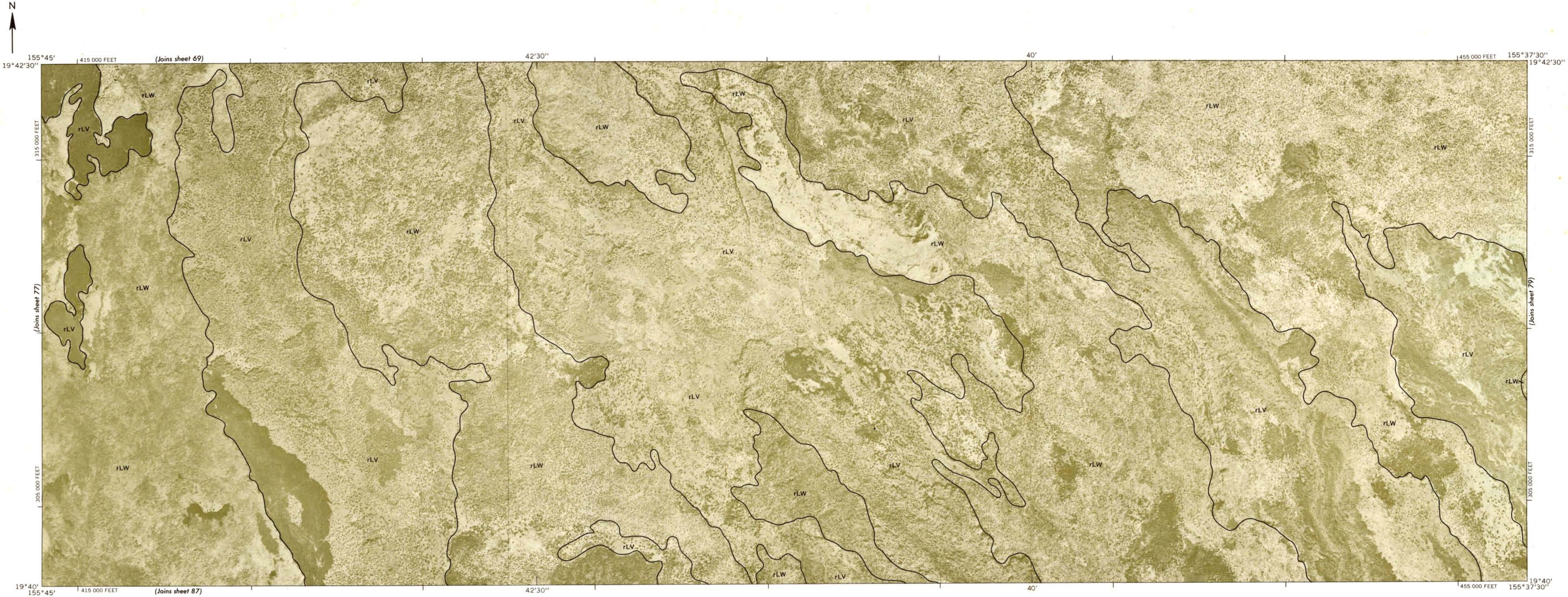


Photobase from 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 1. Old Hawaiian datum.

Scale 1:24 000

1 ¾ ½ ¼ 0 1 2 Miles

5000 4000 3000 2000 1000 0 5000 10000 Feet



Scale 1:24 000

1 ¾ ½ ¼ 0 1 2 Miles

5000 4000 3000 2000 1000 0 5000 10000 Feet

Photobase from 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 1. Old Hawaiian datum.

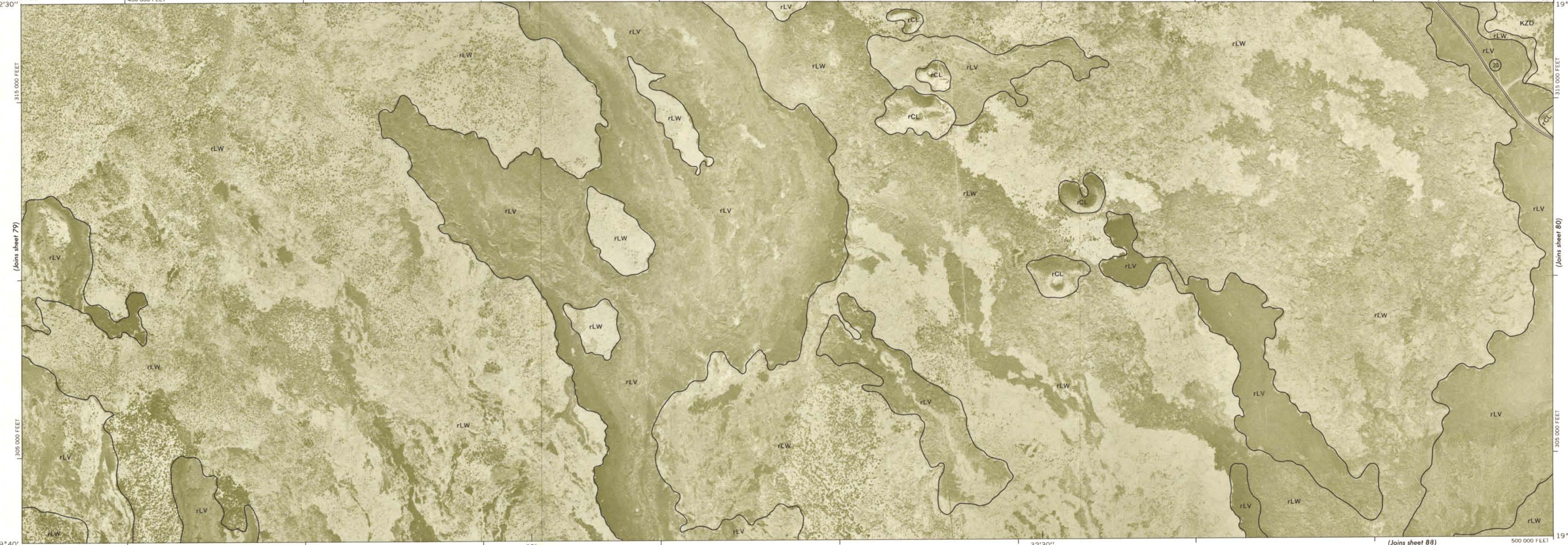
This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the University of Hawaii Agricultural Experiment Station.

N

155°37'30" 460 000 FEET 35' 32'30" (Joins sheet 70) 155°30' 500 000 FEET

19°42'30" 315 000 FEET (Joins sheet 79) 305 000 FEET 19°40'

19°42'30" 315 000 FEET (Joins sheet 80) 305 000 FEET 19°40'



155°37'30" 460 000 FEET 35' 32'30" (Joins sheet 88) 500 000 FEET 155°30'

This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the University of Hawaii Agricultural Experiment Station.

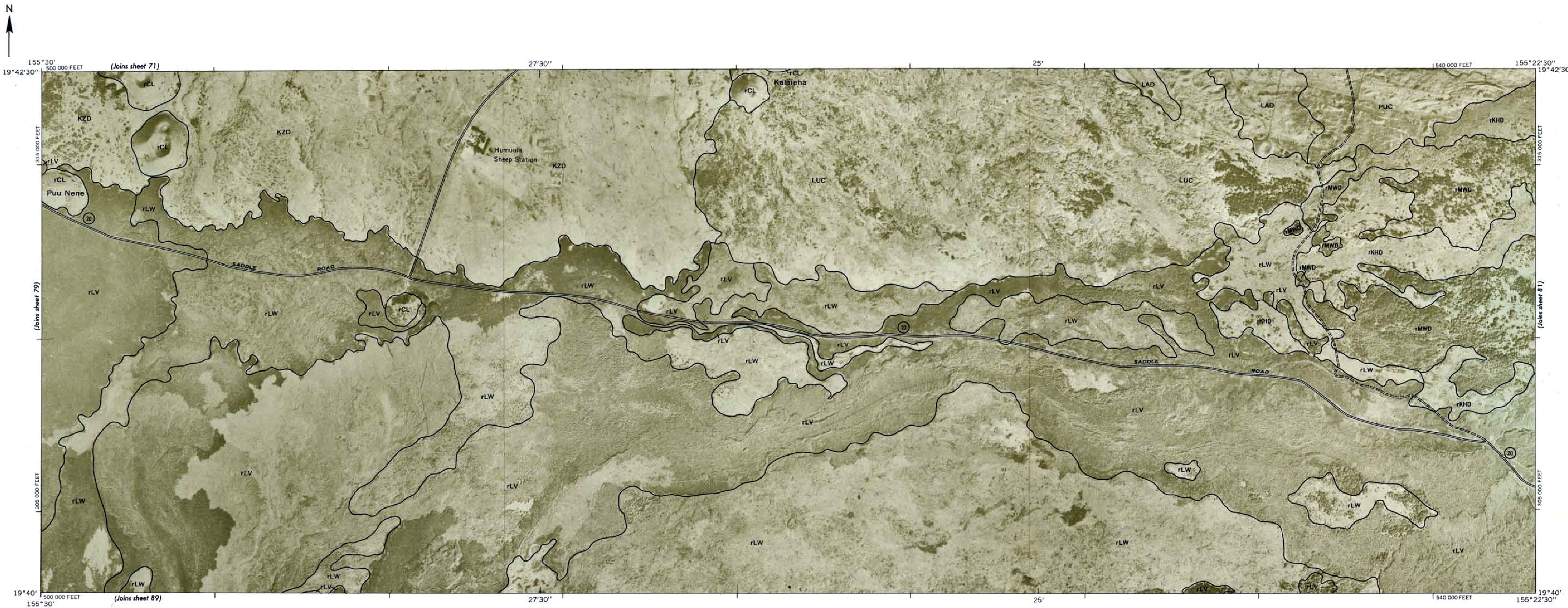
HAWAII ISLAND, HAWAII NO. 79

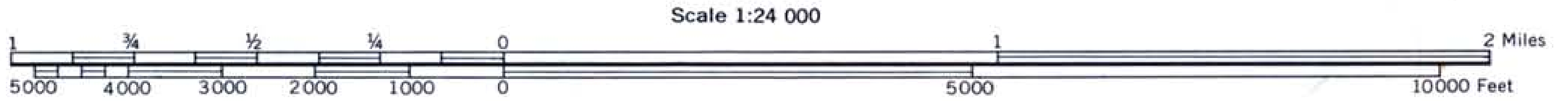
Photobase from 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 1. Old Hawaiian datum.

Scale 1:24 000

1 ¾ ½ ¼ 0 1 2 Miles

5000 4000 3000 2000 1000 0 5000 10000 Feet





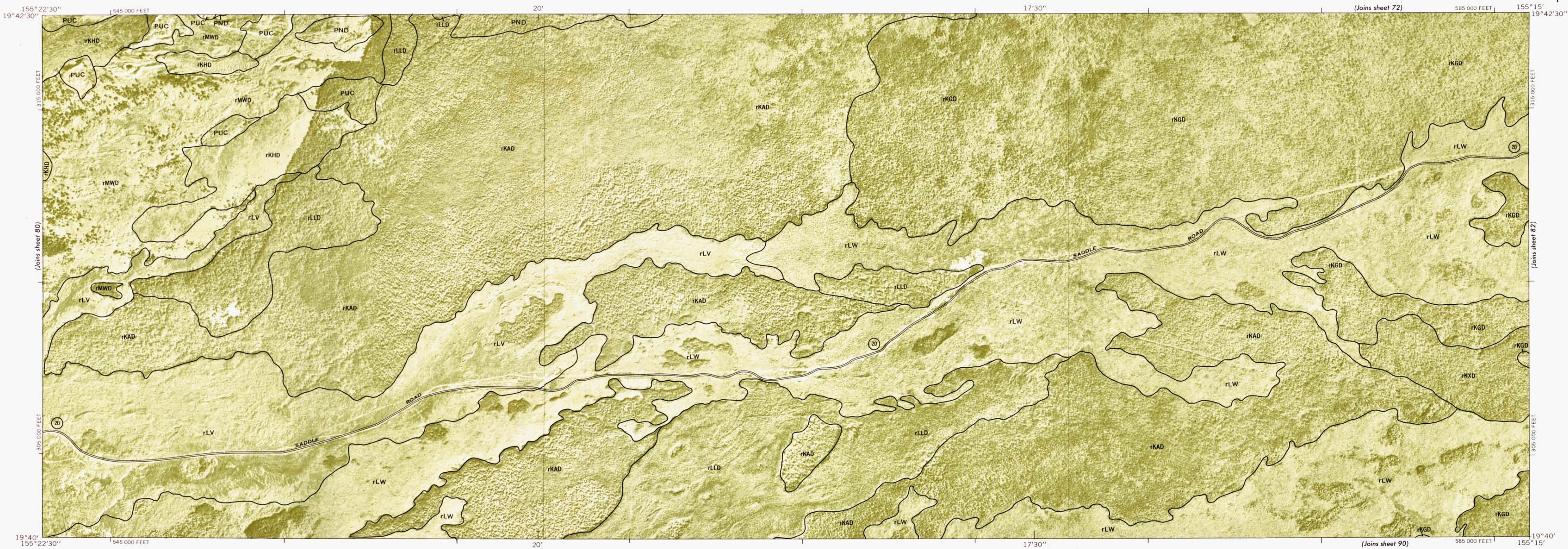
Photobase from 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 1. Old Hawaiian datum.

HAWAII ISLAND, HAWAII NO. 80

This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the University of Hawaii Agricultural Experiment Station.

This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the University of Hawaii Agricultural Experiment Station.

HAWAII ISLAND, HAWAII NO. 81



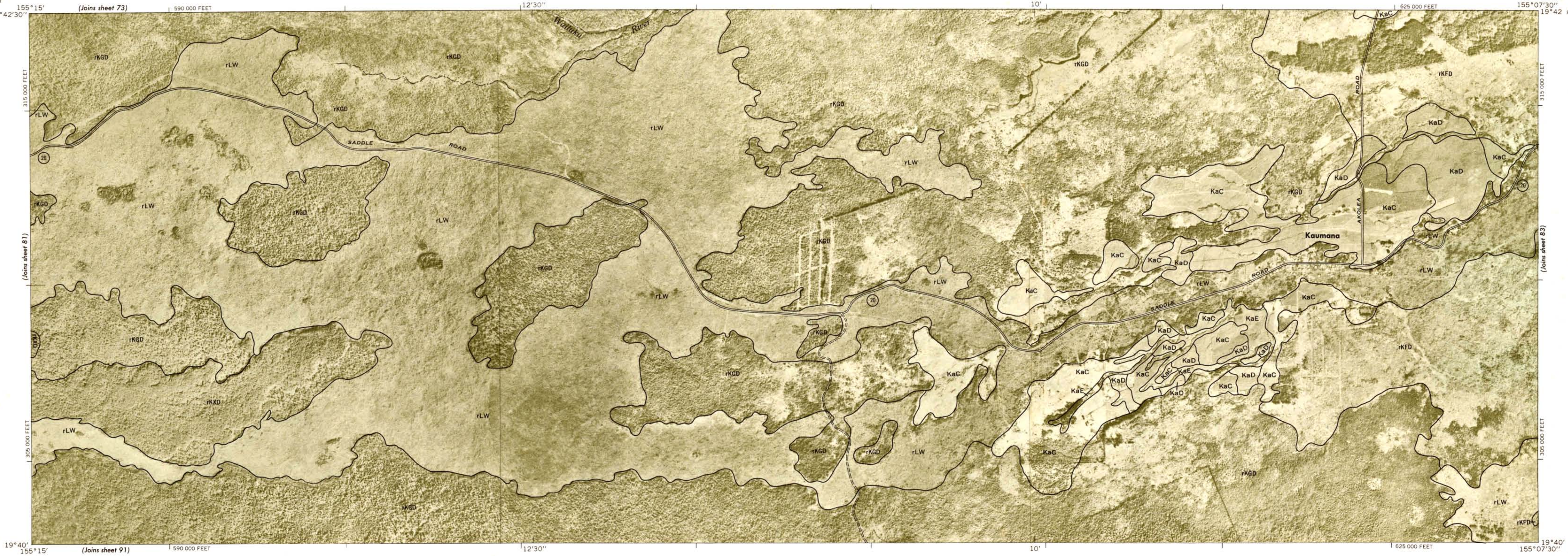
Photobase from 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 1. Old Hawaiian datum.

Scale 1:24 000

1 ¾ ½ ¼ 0 1 2 Miles

5000 4000 3000 2000 1000 0 5000 10000 Feet

N



Scale 1:24 000

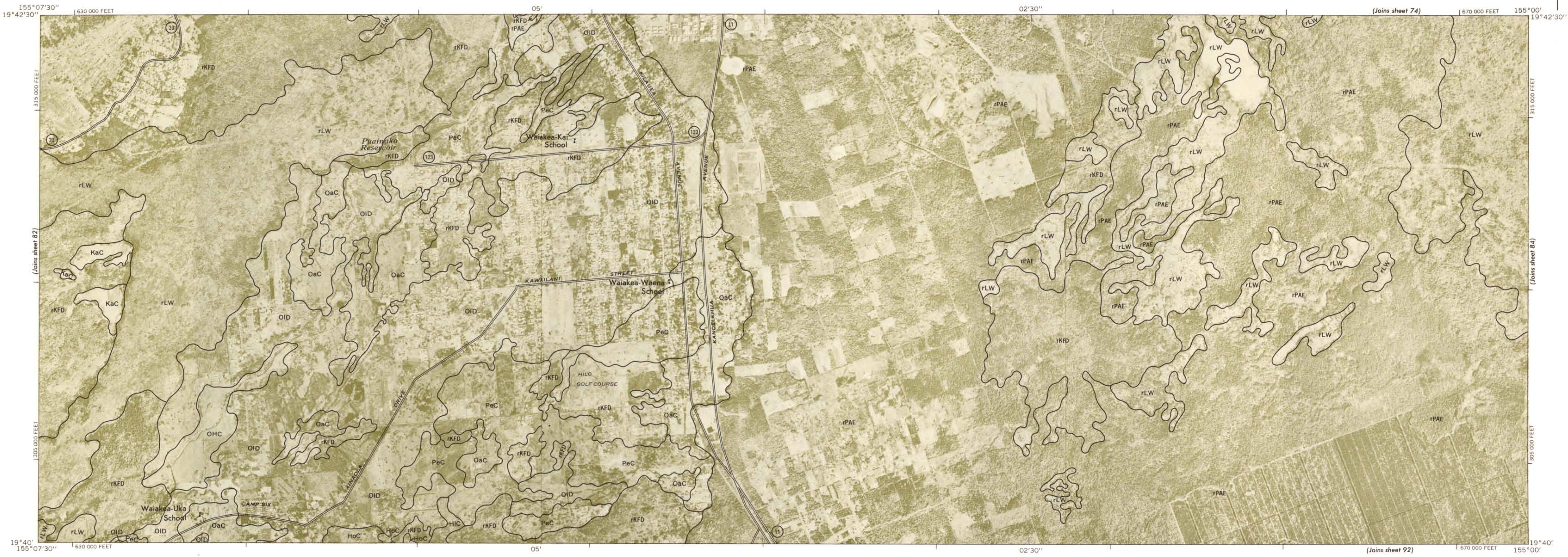
1 ¾ ½ ¼ 0 1 2 Miles

5000 4000 3000 2000 1000 0 5000 10000 Feet

Photobase from 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 1. Old Hawaiian datum.

This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the University of Hawaii Agricultural Experiment Station.

83



This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the University of Hawaii Agricultural Experiment Station.

HAWAII ISLAND, HAWAII NO. 83

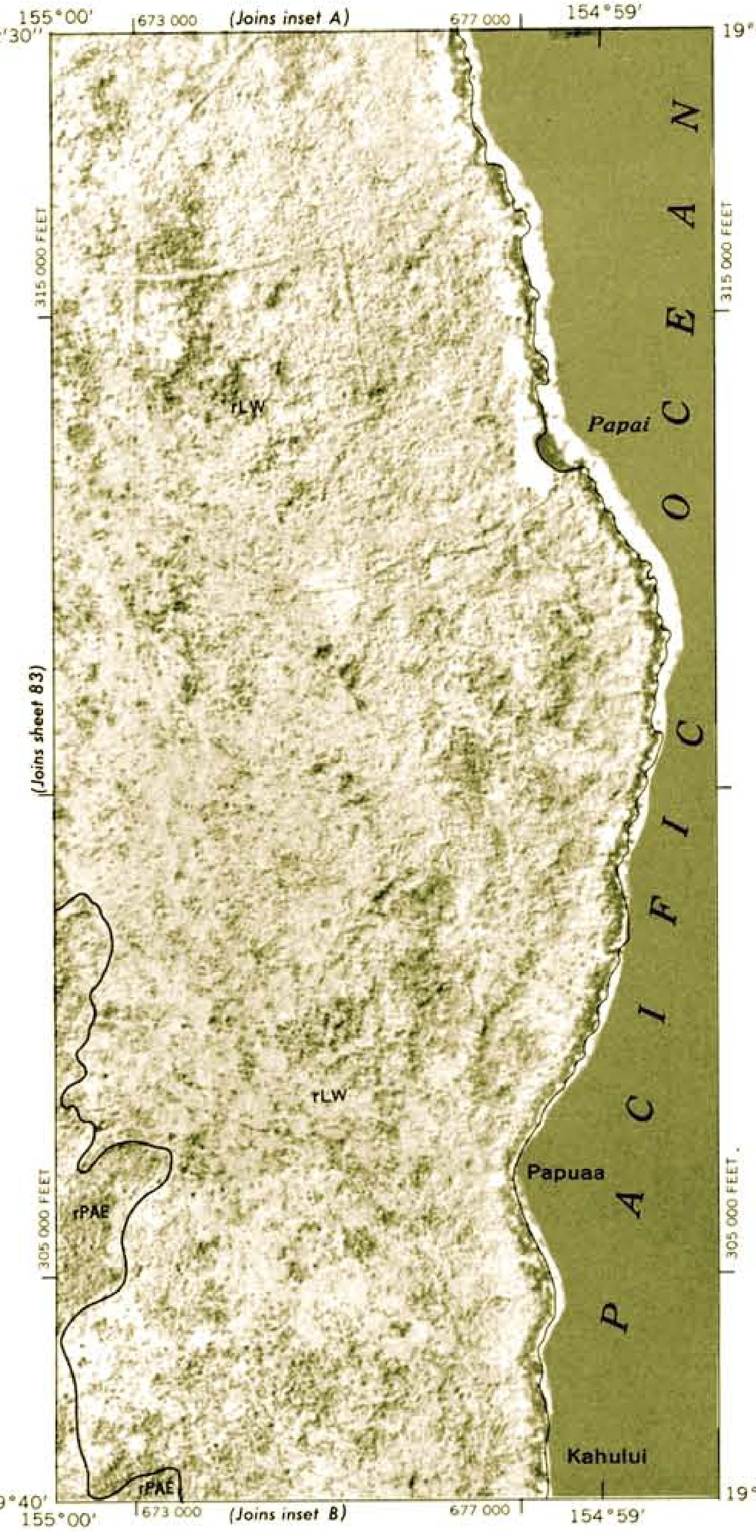
Photobase from 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 1. Old Hawaiian datum.

Scale 1:24 000

1 ¾ ½ ¼ 0 1 2 Miles

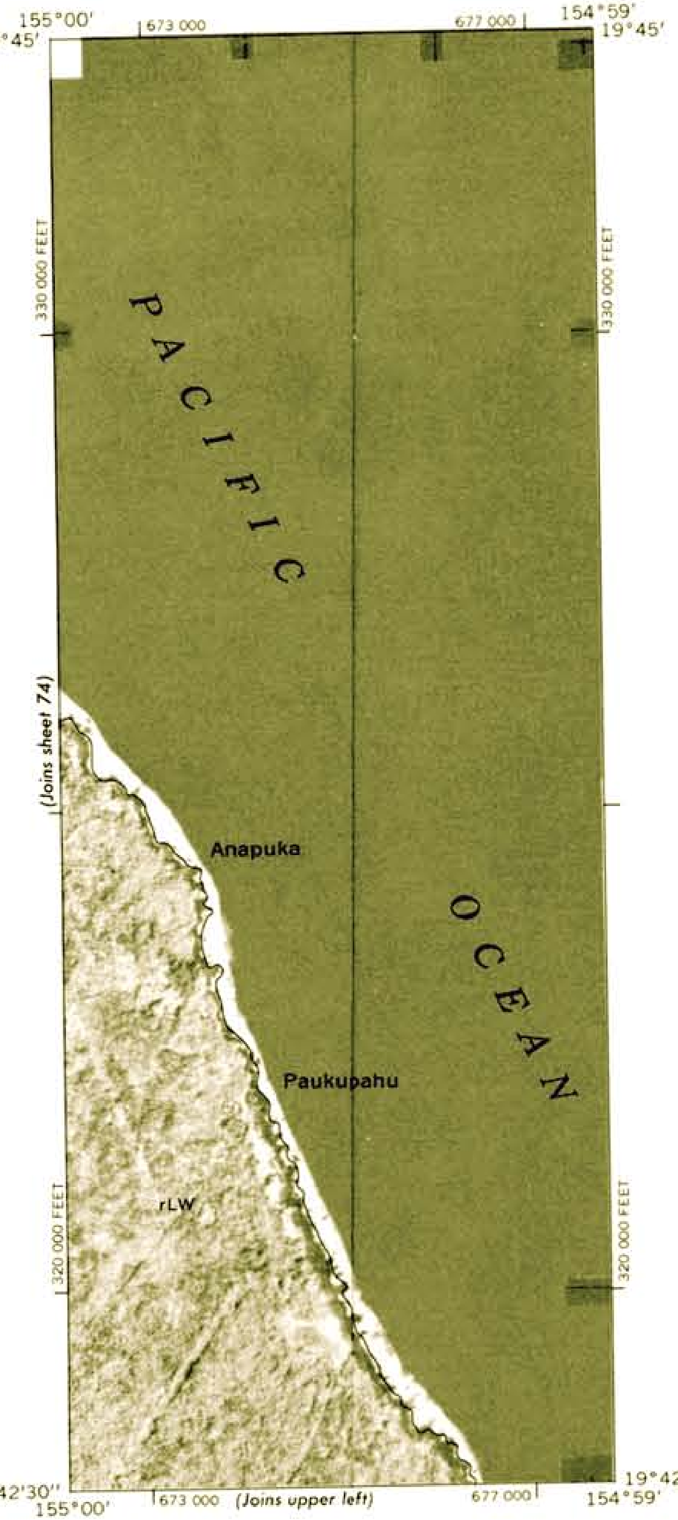
5000 4000 3000 2000 1000 0 5000 10000 Feet

N



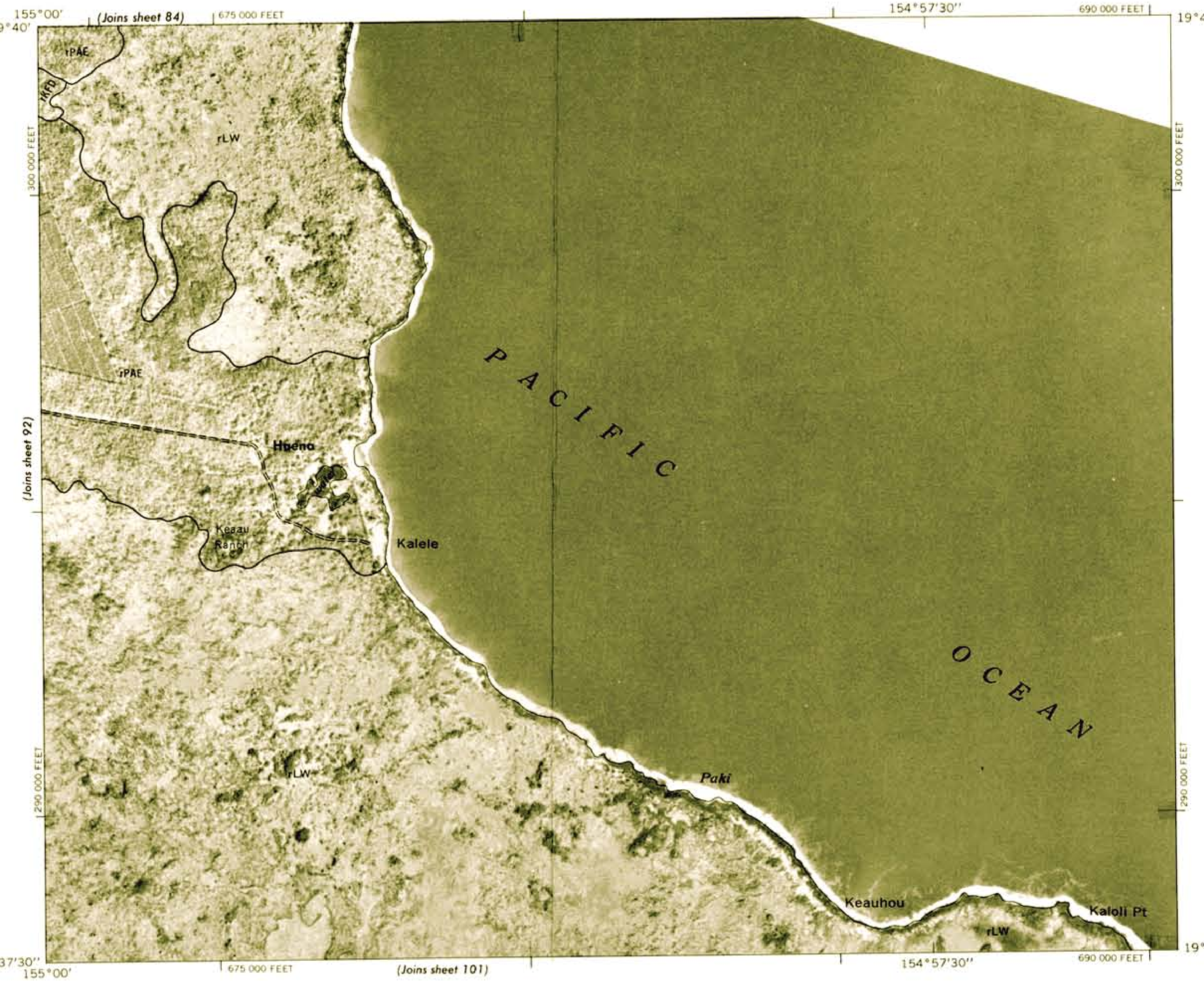
4000 AND 5000-FOOT GRID TICKS

INSET A



4000 AND 5000-FOOT GRID TICKS

INSET B



Scale 1:24 000

1 ¾ ½ ¼ 0 1 2 Miles

5000 4000 3000 2000 1000 0 5000 10000 Feet

Photobase from 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 1. Old Hawaiian datum.

85

N

This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the University of Hawaii Agricultural Experiment Station.

HAWAII ISLAND, HAWAII NO. 85

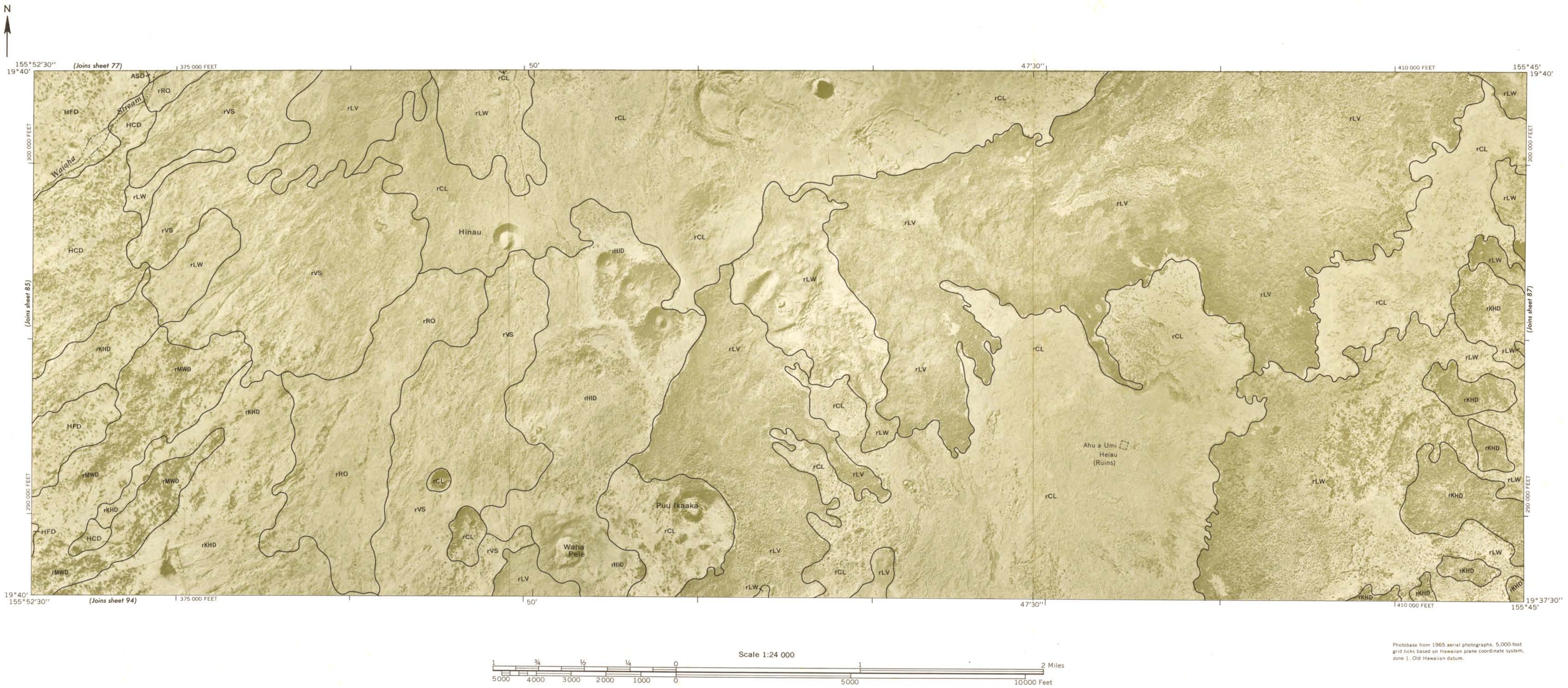
Photobase from 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 1. Old Hawaiian datum.

Scale 1:24 000

1 ¾ ½ ¼ 0 1 2 Miles

5000 4000 3000 2000 1000 0 5000 10000 Feet

HAWAII ISLAND, HAWAII — SHEET NUMBER 86



Photobase from 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 1. Old Hawaiian datum.

HAWAII ISLAND, HAWAII NO. 86

This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the University of Hawaii Agricultural Experiment Station.

N

Photobase from 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 1. Old Hawaiian datum

Scale 1:24 000

1 ¾ ½ ¼ 0 1 2 Miles

5000 4000 3000 2000 1000 0 5000 10000 Feet

This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the University of Hawaii Agricultural Experiment Station.

HAWAII ISLAND, HAWAII NO. 87

Scale 1:24 000

1 ¾ ½ ¼ 0 1 2 Miles

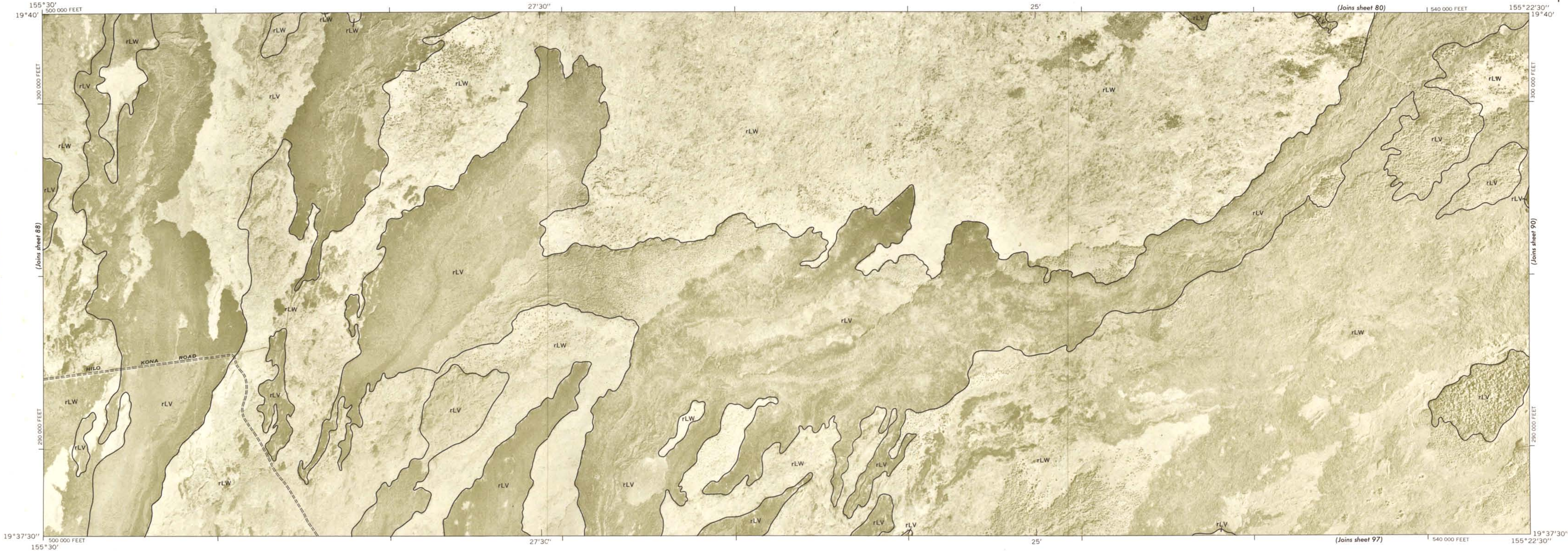
5000 4000 3000 2000 1000 0 5000 10000 Feet

Photobase from 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 1. Old Hawaiian datum.

N

This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the University of Hawaii Agricultural Experiment Station.

HAWAII ISLAND, HAWAII NO. 89



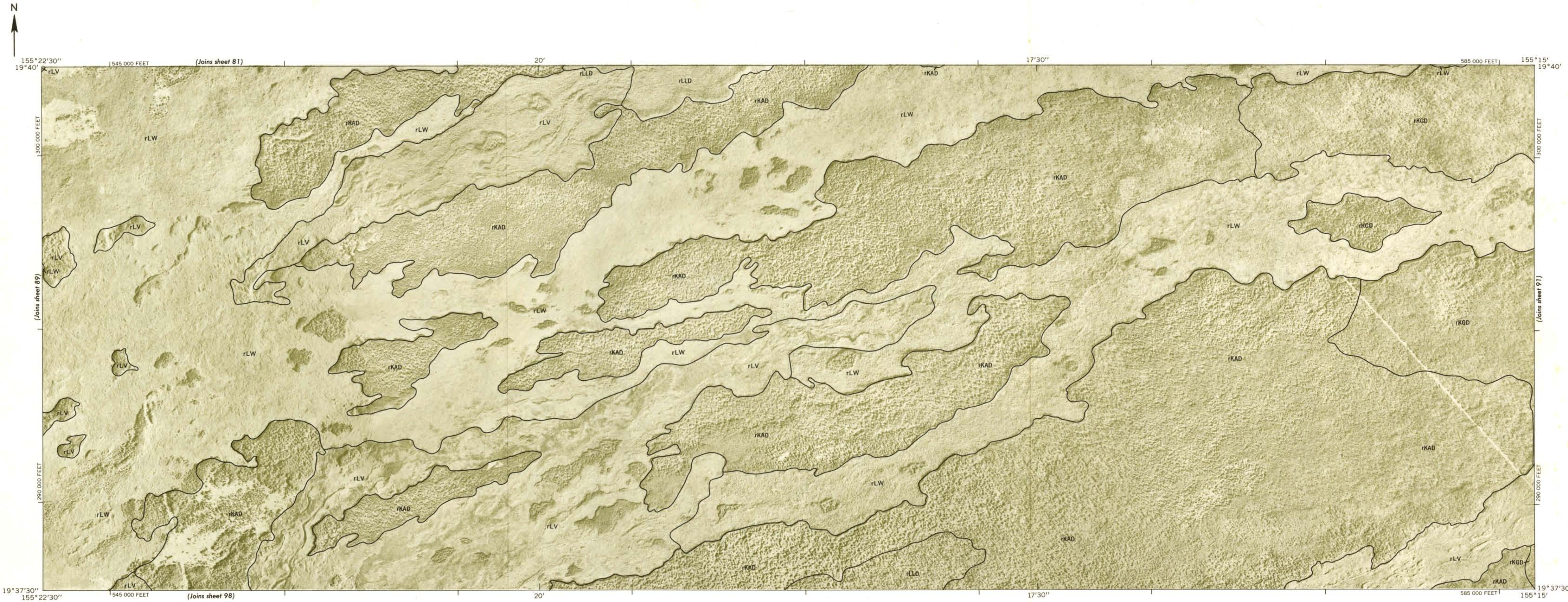
Photobase from 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 1. Old Hawaiian datum.

Scale 1:24 000

1 ¼ ½ ¼ 0 1 2 Miles

5000 4000 3000 2000 1000 0 5000 10000 Feet

HAWAII ISLAND, HAWAII — SHEET NUMBER 90



Scale 1:24 000

1 ¾ ½ ¼ 0 1 2 Miles

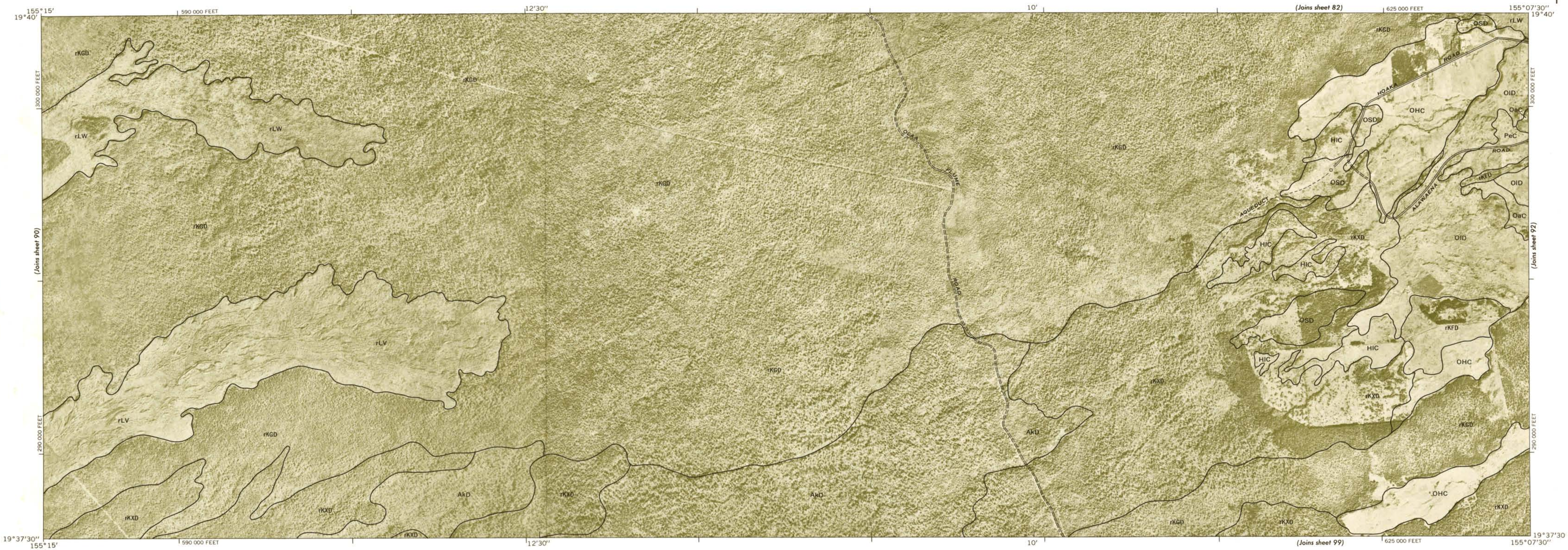
5000 4000 3000 2000 1000 0 5000 10000 Feet

Photobase from 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 1. Old Hawaiian datum.

This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the University of Hawaii Agricultural Experiment Station.

HAWAII ISLAND, HAWAII NO. 90

N



This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the University of Hawaii Agricultural Experiment Station.

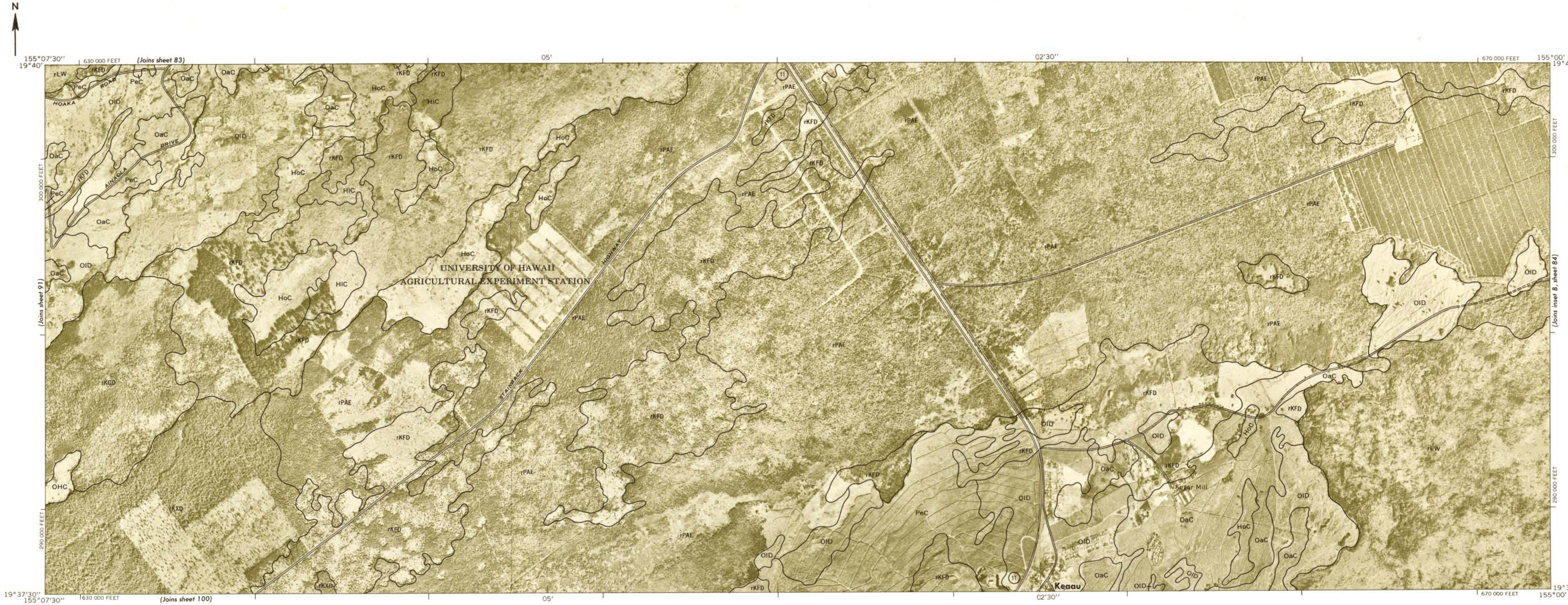
HAWAII ISLAND, HAWAII NO. 91

Photobase from 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 1. Old Hawaiian datum.

Scale 1:24 000

1 ¾ ½ ¼ 0 1 2 Miles

5000 4000 3000 2000 1000 0 5000 10000 Feet



Scale 1:24 000

1 ¾ ½ ¼ 0 1 2 Miles

5000 4000 3000 2000 1000 0 5000 10000 Feet

Photobase from 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 1. Old Hawaiian datum.

HAWAII ISLAND, HAWAII NO. 92

This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the University of Hawaii Agricultural Experiment Station

This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the University of Hawaii Agricultural Experiment Station.

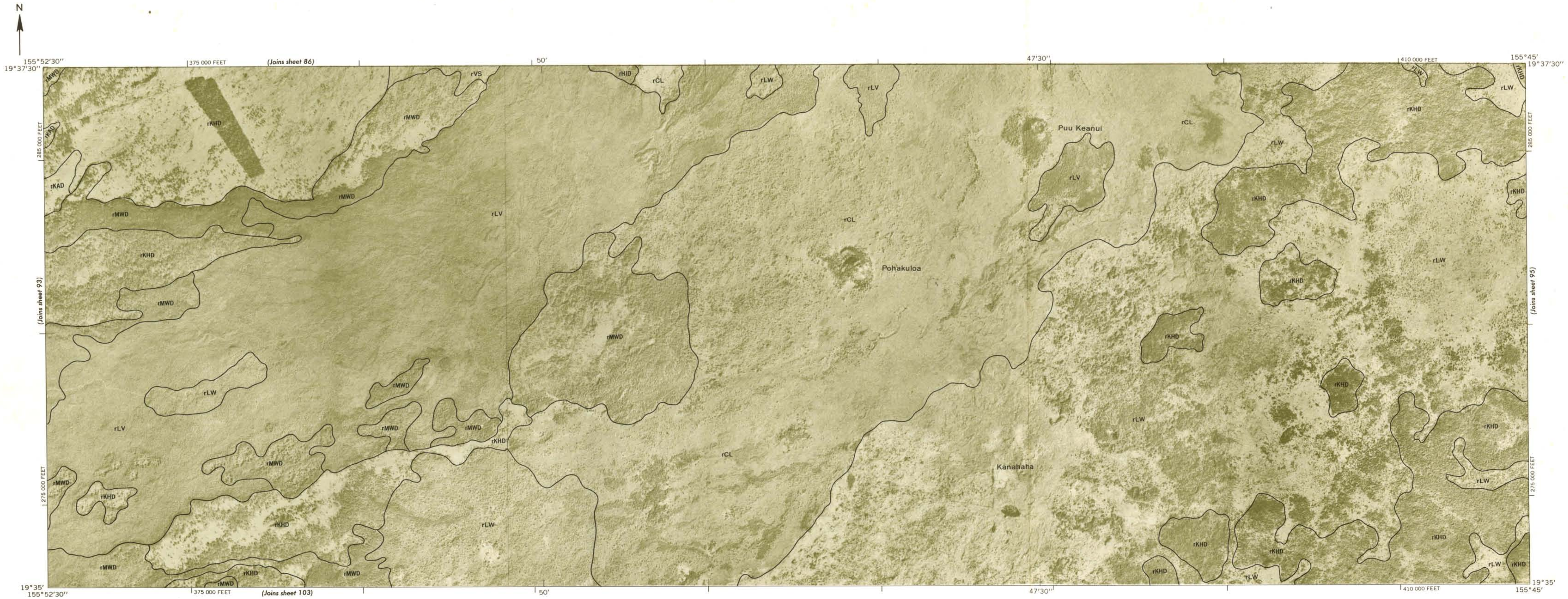
HAWAII ISLAND, HAWAII NO. 93

Photobase from 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 1. Old Hawaiian datum.

Scale 1:24 000

1 ¾ ½ ¼ 0 1 2 Miles

5000 4000 3000 2000 1000 0 5000 10000 Feet



Scale 1:24 000

1 ¾ ½ ¼ 0 1 2 Miles

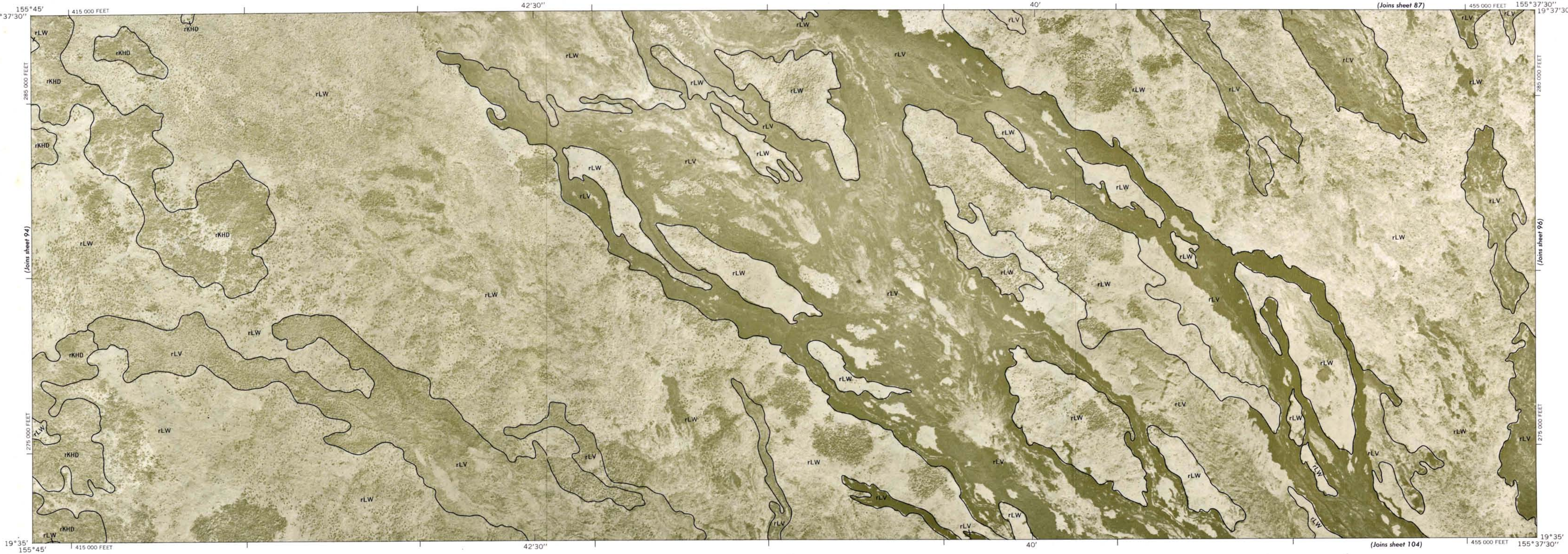
5000 4000 3000 2000 1000 0 5000 10000 Feet

Photobase from 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 1. Old Hawaiian datum.

N

This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the University of Hawaii Agricultural Experiment Station.

HAWAII ISLAND, HAWAII NO. 95



Photobase from 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 1. Old Hawaiian datum.

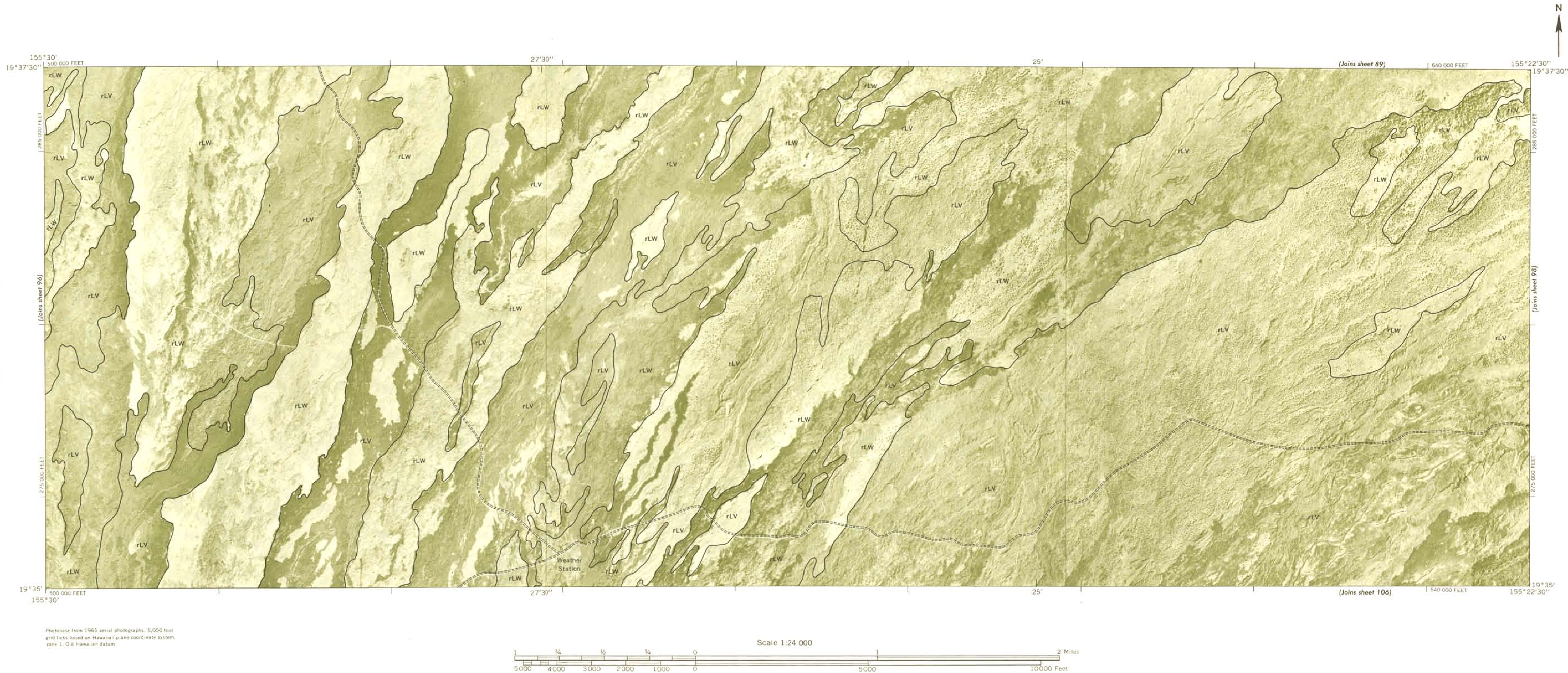
Scale 1:24 000

1 ¾ ½ ¼ 0 1 2 Miles

5000 4000 3000 2000 1000 0 5000 10000 Feet

Photobase from 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 1. Old Hawaiian datum.

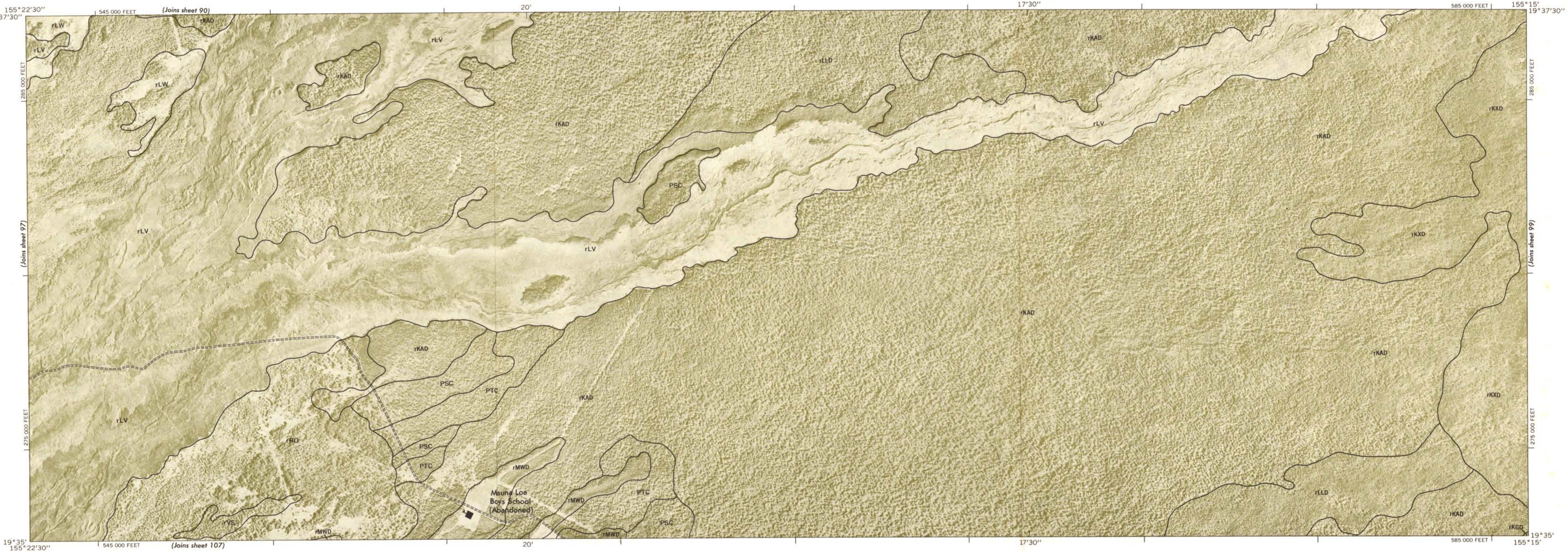
HAWAII ISLAND, HAWAII NO. 97



Photobase from 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 1, Old Hawaiian datum.

HAWAII ISLAND, HAWAII — SHEET NUMBER 98

N



Scale 1:24 000

1 ¾ ½ ¼ 0 1 2 Miles

5000 4000 3000 2000 1000 0 5000 10000 Feet

Photobase from 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 1. Old Hawaiian datum.

HAWAII ISLAND, HAWAII NO. 98

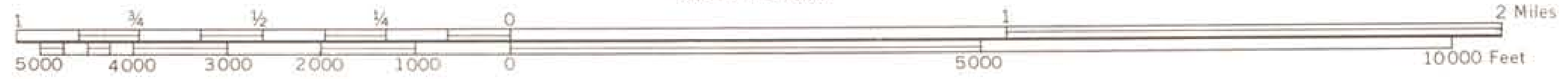
This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the University of Hawaii Agricultural Experiment Station.

This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the University of Hawaii Agricultural Experiment Station.

HAWAII ISLAND, HAWAII NO. 99

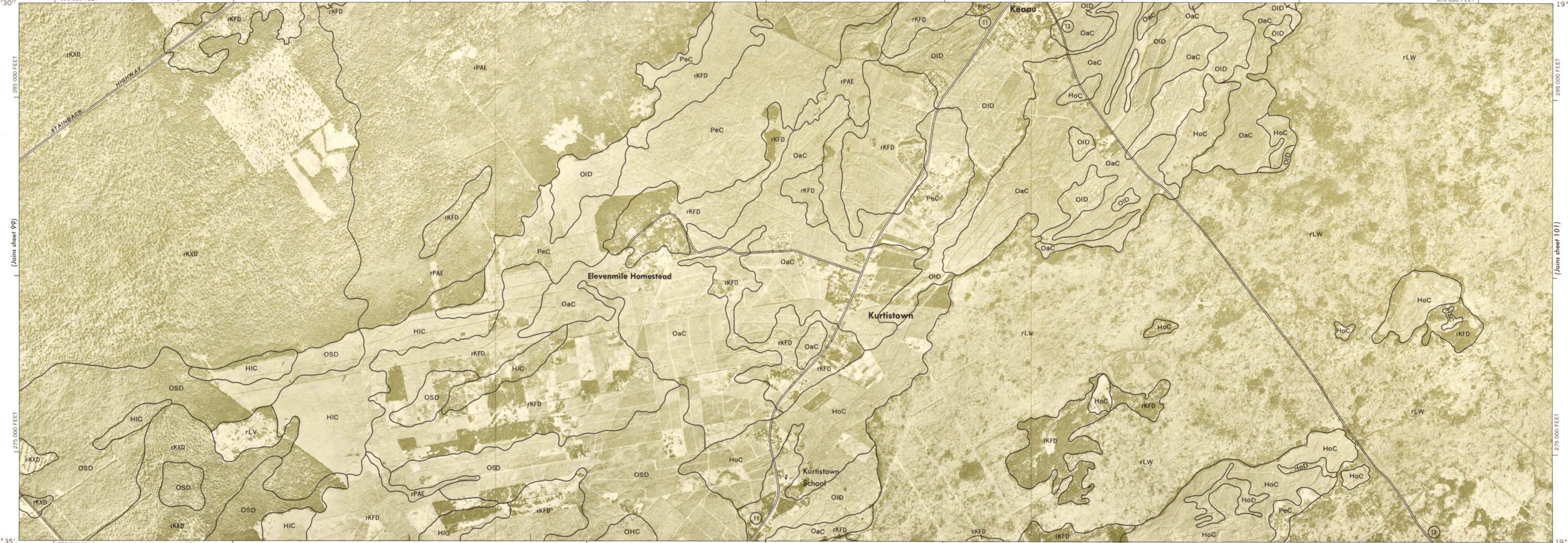
Photobase from 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 1. Old Hawaiian datum.

Scale 1:24 000



N

155°07'30" 19°37'30" 630 000 FEET (Joins sheet 92) 05' 02'30" 670 000 FEET 155°00' 19°37'30"



(Joins sheet 99) 285 000 FEET 275 000 FEET (Joins sheet 101)

19°35' 155°07'30" 630 000 FEET (Joins sheet 109) 05' 02'30" 670 000 FEET 155°00' 19°35'

Scale 1:24 000

1 ¾ ½ ¼ 0 1 2 Miles

5000 4000 3000 2000 1000 0 5000 10000 Feet

Photobase from 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 1. Old Hawaiian datum.

HAWAII ISLAND, HAWAII NO. 100

This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the University of Hawaii Agricultural Experiment Station.

N

This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the University of Hawaii Agricultural Experiment Station.

HAWAII ISLAND, HAWAII NO. 101

Photobase from 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 1. Old Hawaiian datum.

Scale 1:24 000

1 ¾ ½ ¼ 0 1 2 Miles

5000 4000 3000 2000 1000 0 5000 10000 Feet

HAWAII ISLAND, HAWAII — SHEET NUMBER 102

N

Photobase from 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 1. Old Hawaiian datum.

Scale 1:24 000

1 ¾ ½ ¼ 0 1 2 Miles

5000 4000 3000 2000 1000 0 5000 10000 Feet

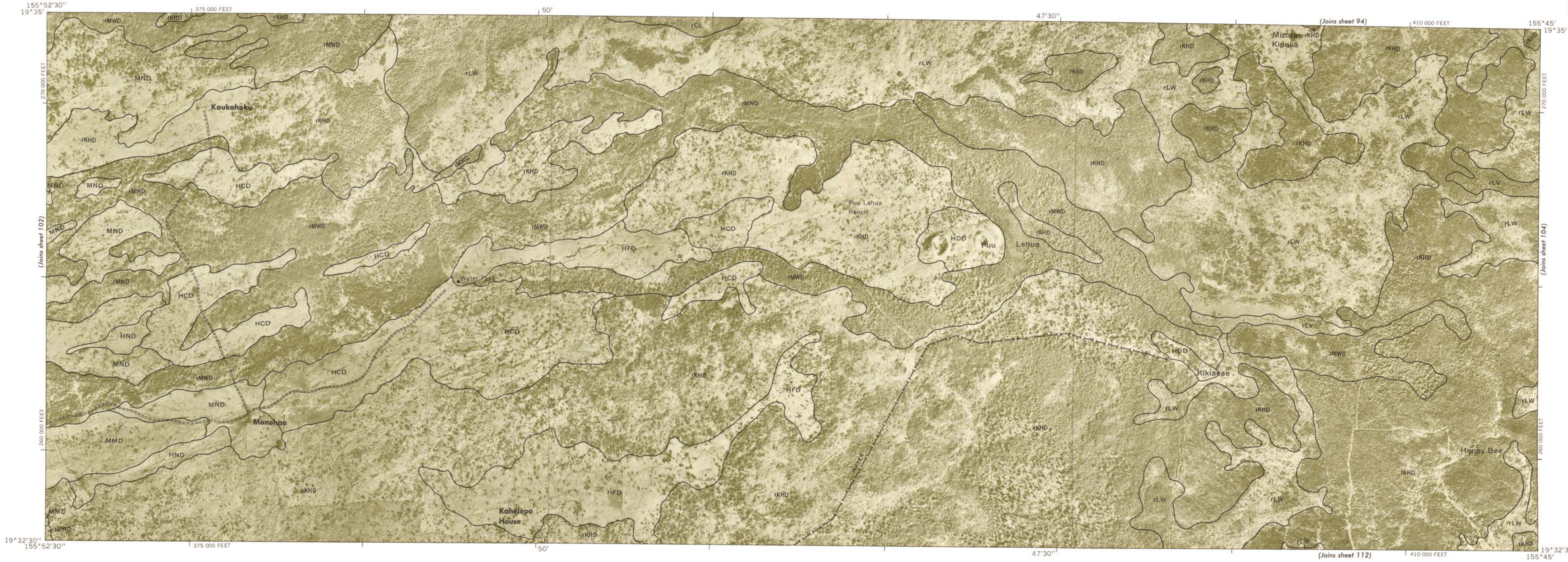
This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the University of Hawaii Agricultural Experiment Station.

HAWAII ISLAND, HAWAII NO. 102

N

This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the University of Hawaii Agricultural Experiment Station.

HAWAII ISLAND, HAWAII NO. 103



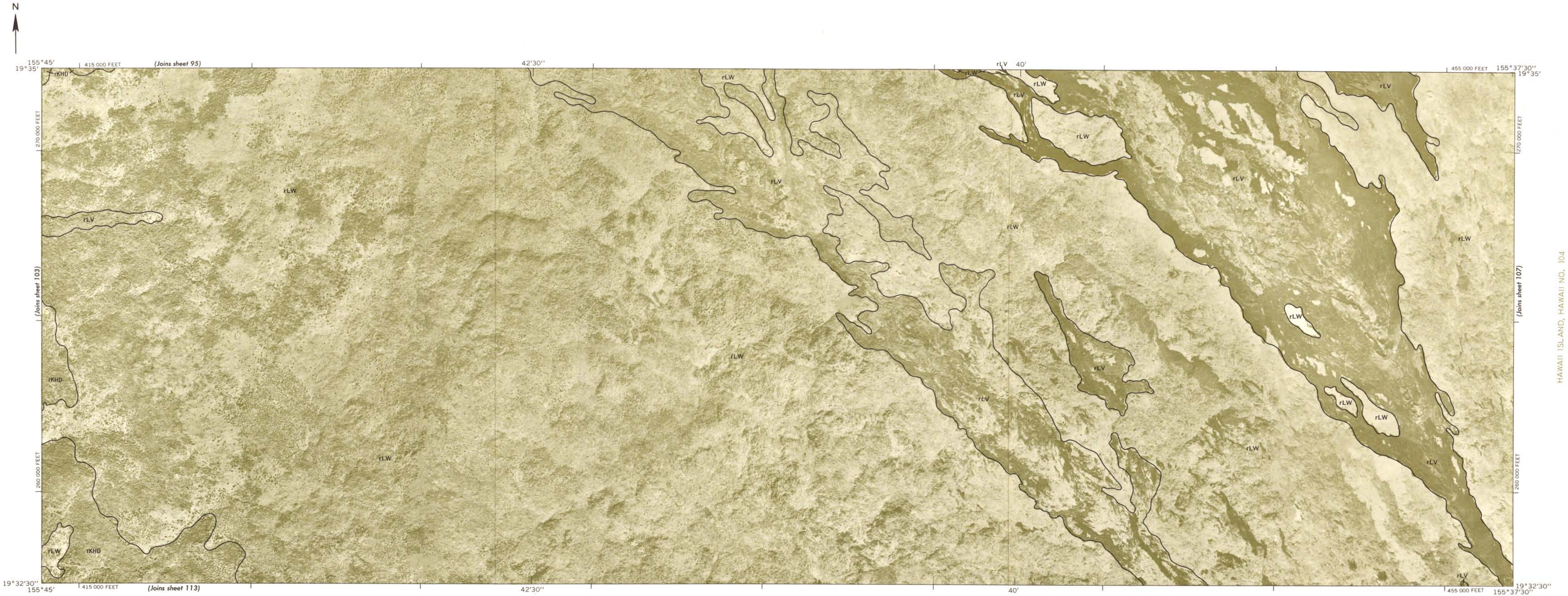
Photobase from 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 1. Old Hawaiian datum.

Scale 1:24 000

1 ¾ ½ ¼ 0 1 2 Miles

5000 4000 3000 2000 1000 0 5000 10000 Feet

HAWAII ISLAND, HAWAII — SHEET NUMBER 104



Scale 1:24 000

Photobase from 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 1. Old Hawaiian datum.

HAWAII ISLAND, HAWAII NO. 104

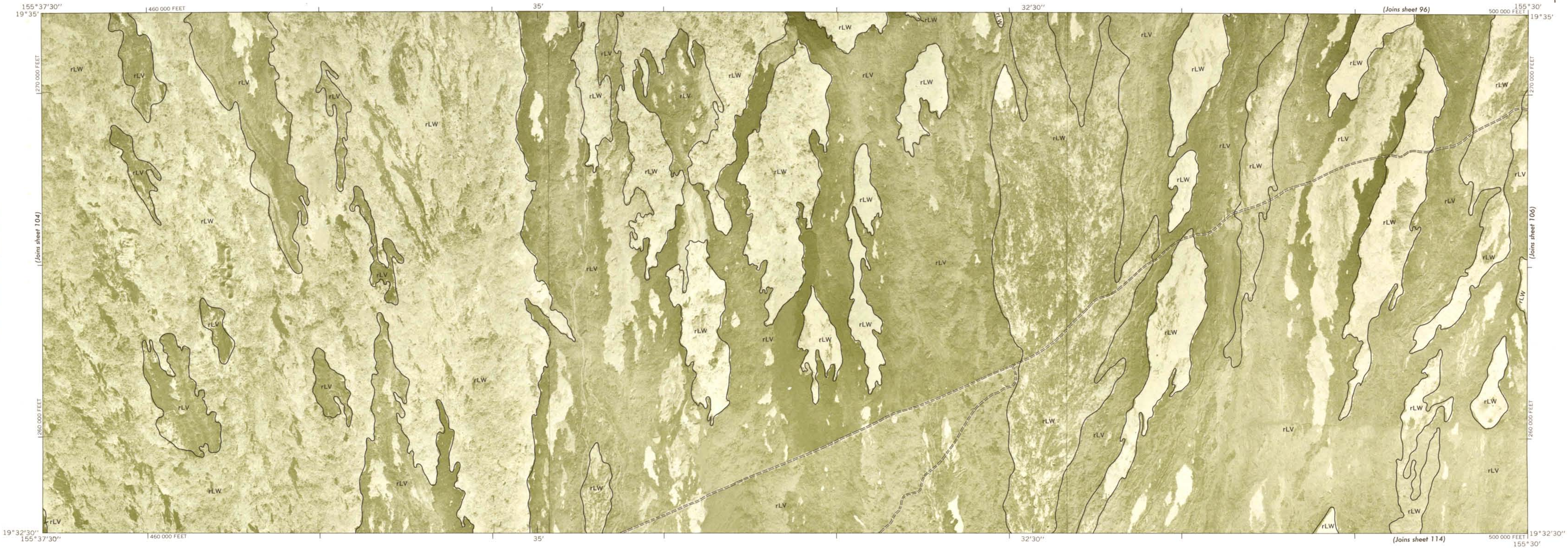
HAWAII ISLAND, HAWAII — SHEET NUMBER 105

105

N

This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the University of Hawaii Agricultural Experiment Station.

HAWAII ISLAND, HAWAII NO. 105



Photobase from 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 1. Old Hawaiian datum.

Scale 1:24 000

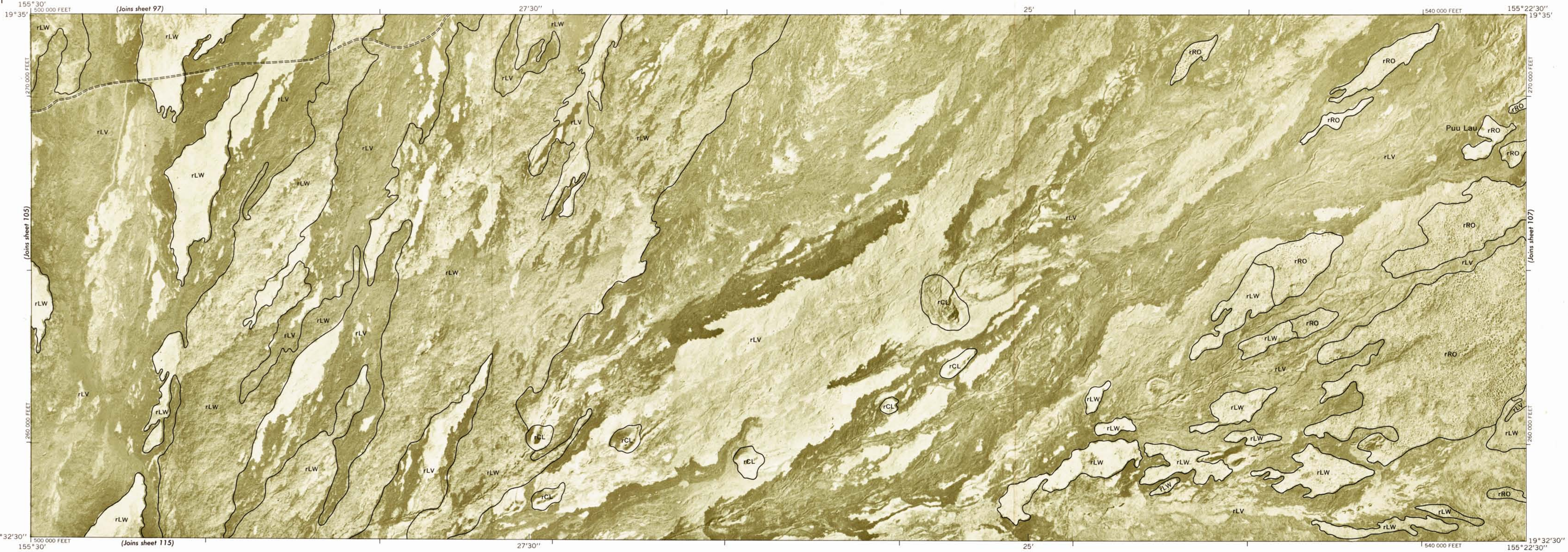
1 ¾ ½ ¼ 0 1 2 Miles

5000 4000 3000 2000 1000 0 5000 10000 Feet

106

HAWAII ISLAND, HAWAII — SHEET NUMBER 106

N



Scale 1:24 000

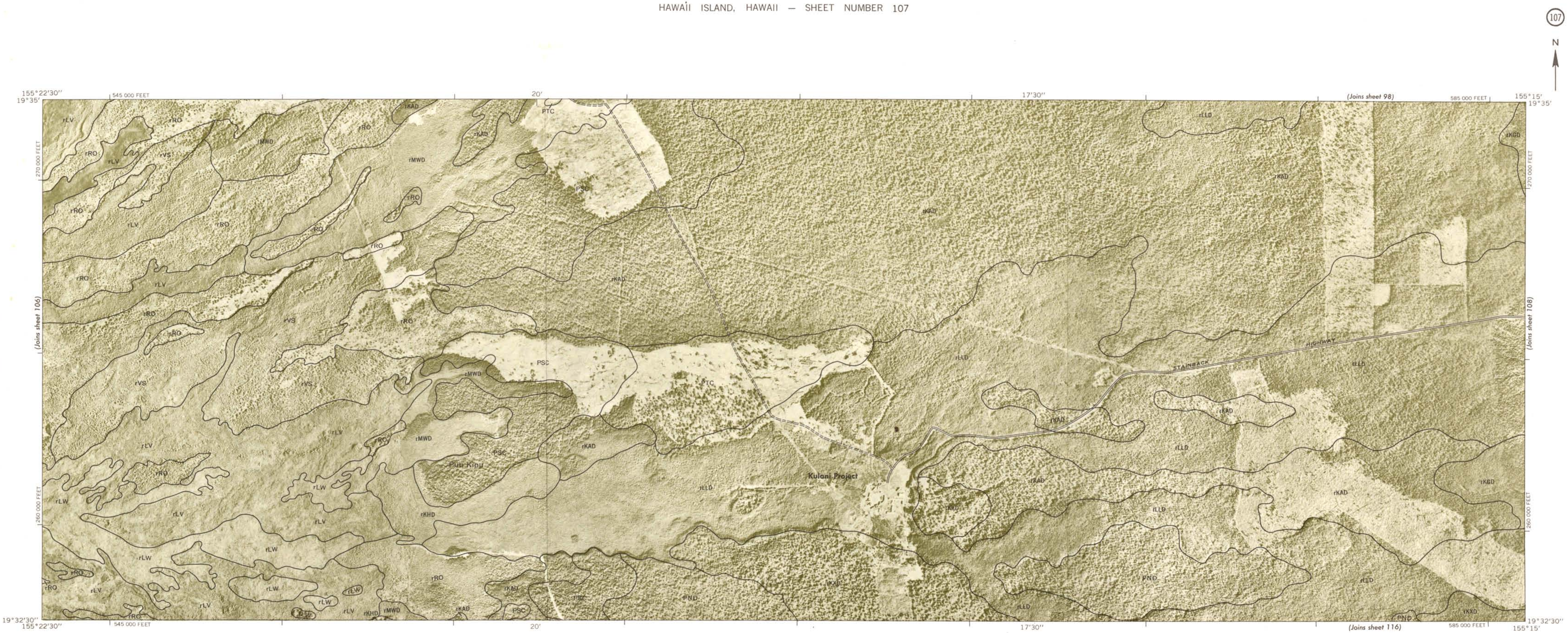
1 ¾ ½ ¼ 0 1 2 Miles

5000 4000 3000 2000 1000 0 5000 10000 Feet

Photobase from 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 1. Old Hawaiian datum.

HAWAII ISLAND, HAWAII NO. 106

This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the University of Hawaii Agricultural Experiment Station.



This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the University of Hawaii Agricultural Experiment Station.

HAWAII ISLAND, HAWAII NO. 107

Photobase from 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 1. Old Hawaiian datum.

Scale 1:24 000

1 ¾ ½ ¼ 0 1 2 Miles

5000 4000 3000 2000 1000 0 5000 10000 Feet

HAWAII ISLAND, HAWAII — SHEET NUMBER 108

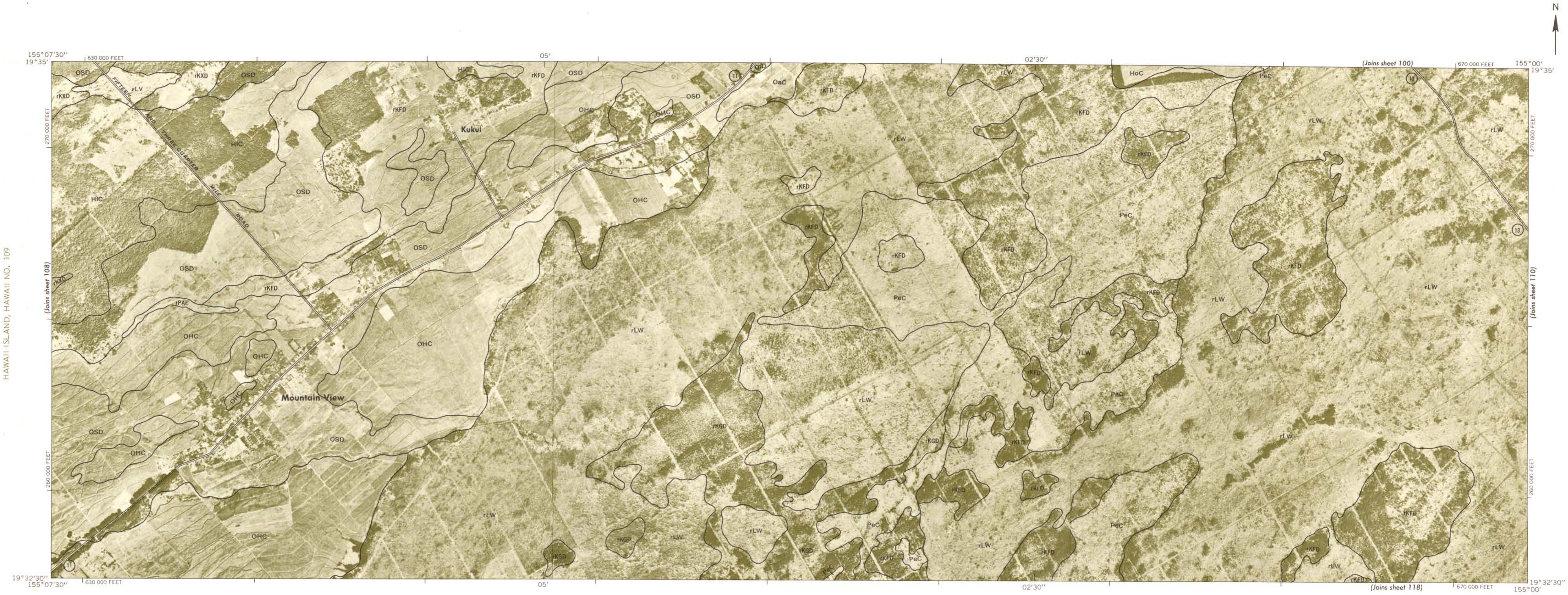
Scale 1:24 000

1 ¾ ½ ¼ 0 1 2 Miles

5000 4000 3000 2000 1000 0 5000 10000 Feet

Photobase from 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 1. Old Hawaiian datum.

This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the University of Hawaii Agricultural Experiment Station —



This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the University of Hawaii Agricultural Experiment Station.

HAWAII ISLAND, HAWAII NO. 109

Photobase from 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 1. Old Hawaiian datum.

Scale 1:24 000

1 ¾ ½ ¼ 0 1 2 Miles

5000 4000 3000 2000 1000 0 5000 10000 Feet

HAWAII ISLAND, HAWAII — SHEET NUMBER 110

Scale 1:24 000

1 ¾ ½ ¼ 0 1 2 Miles

5000 4000 3000 2000 1000 0 5000 10000 Feet

Photobase from 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 1. Old Hawaiian datum.

HAWAII ISLAND, HAWAII NO. 110

This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the University of Hawaii Agricultural Experiment Station.

This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the University of Hawaii Agricultural Experiment Station.

HAWAII ISLAND, HAWAII NO. 111

Photobase from 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 1. Old Hawaiian datum.

Scale 1:24 000

1 ¾ ½ ¼ 0 1 2 Miles

5000 4000 3000 2000 1000 0 5000 10000 Feet

HAWAII ISLAND, HAWAII — SHEET NUMBER 112

Scale 1:24 000

1 ¾ ½ ¼ 0 1 2 Miles

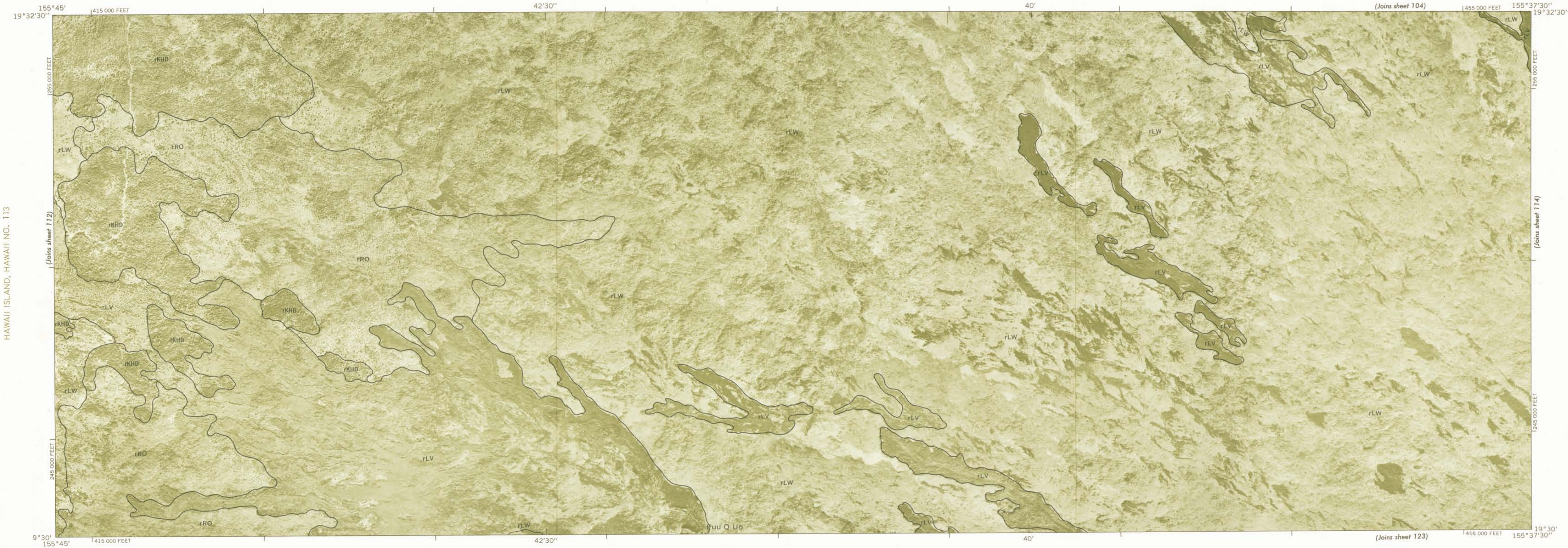
5000 4000 3000 2000 1000 0 5000 10000 Feet

Photobase from 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 1. Old Hawaiian datum.

HAWAII ISLAND, HAWAII NO. 112

This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the University of Hawaii Agricultural Experiment Station.

N



This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the University of Hawaii Agricultural Experiment Station.

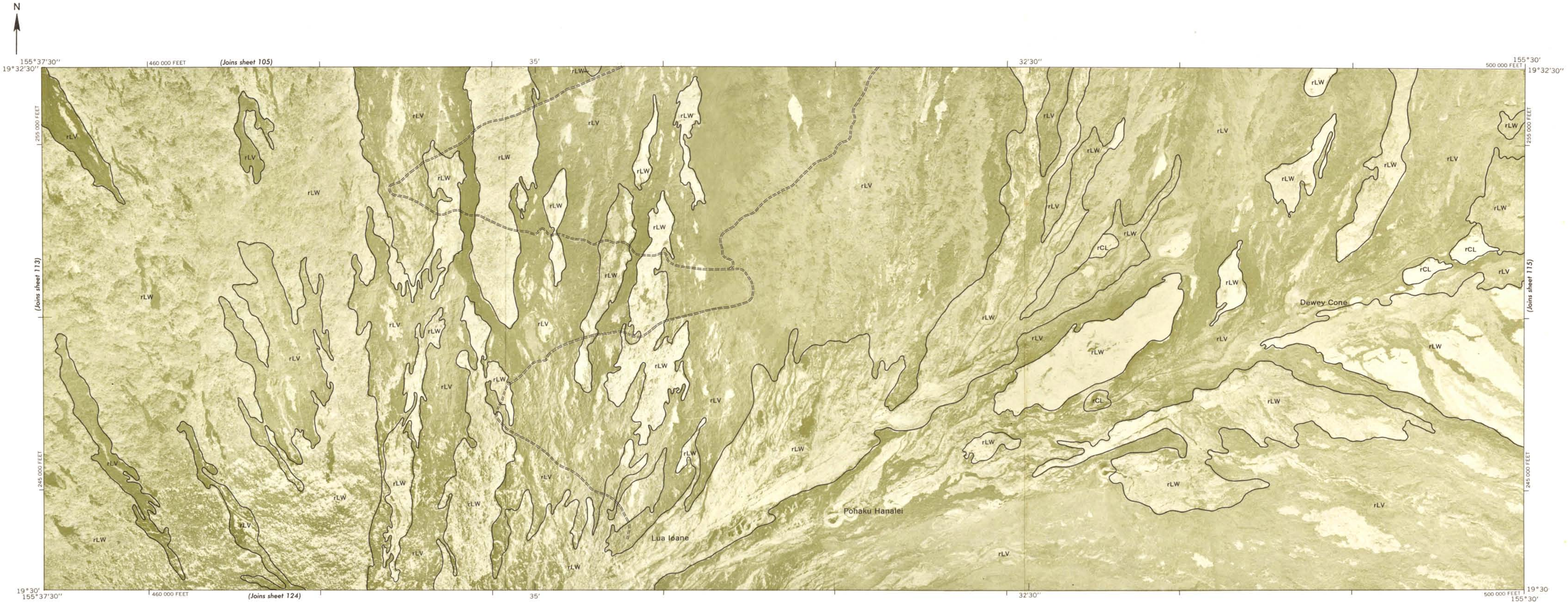
HAWAII ISLAND, HAWAII NO. 113

Photobase from 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 1. Old Hawaiian datum.

Scale 1:24 000

1 ¾ ½ ¼ 0 1 2 Miles

5000 4000 3000 2000 1000 0 5000 10000 Feet



Scale 1:24 000

Photobase from 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 1. Old Hawaiian datum.

This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the University of Hawaii Agricultural Experiment Station.

115

N

This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the University of Hawaii Agricultural Experiment Station.

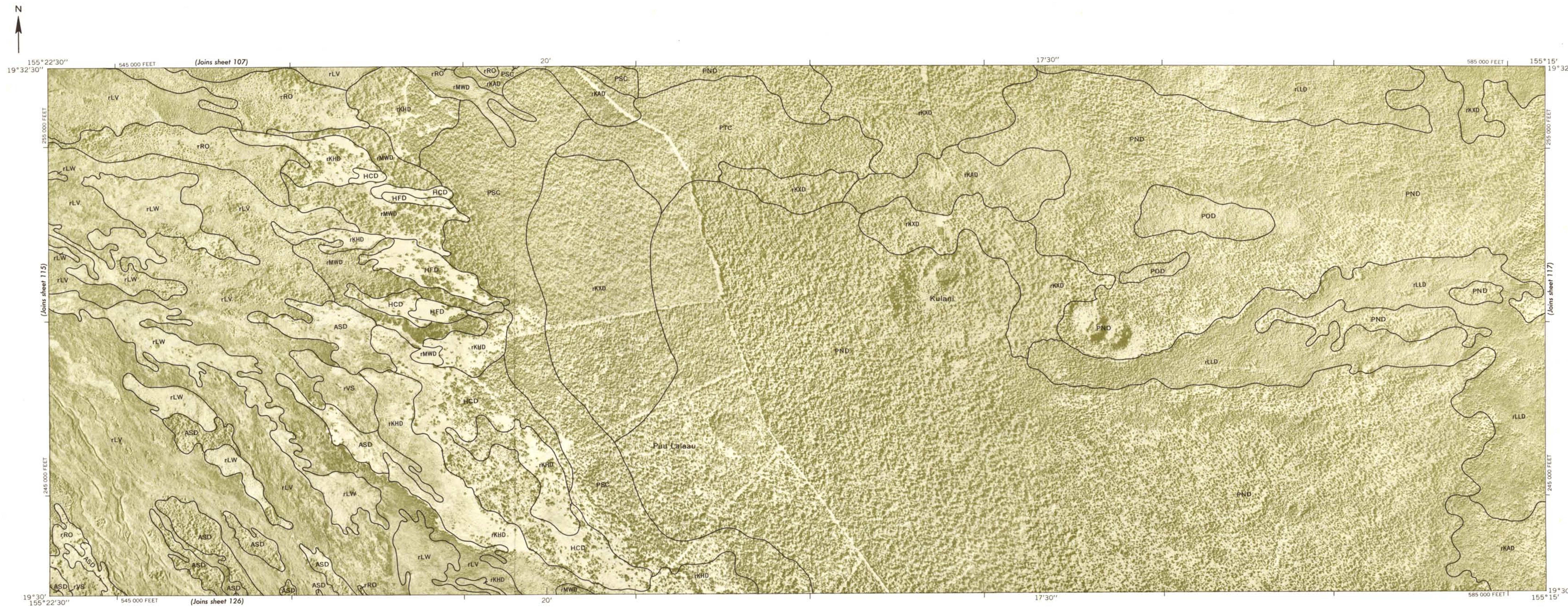
HAWAII ISLAND, HAWAII NO. 115

Photobase from 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 1. Old Hawaiian datum.

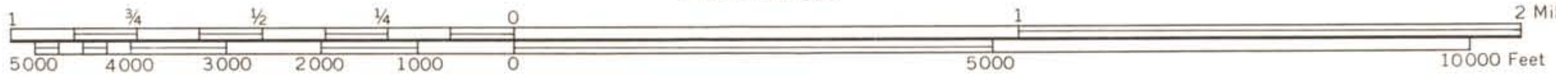
Scale 1:24 000

1 ¾ ½ ¼ 0 1 2 Miles

5000 4000 3000 2000 1000 0 5000 10000 Feet



Scale 1:24 000



Photobase from 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 1. Old Hawaiian datum.

HAWAII ISLAND, HAWAII NO. 116

This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the University of Hawaii Agricultural Experiment Station.

N

This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the University of Hawaii Agricultural Experiment Station.

HAWAII ISLAND, HAWAII NO. 117

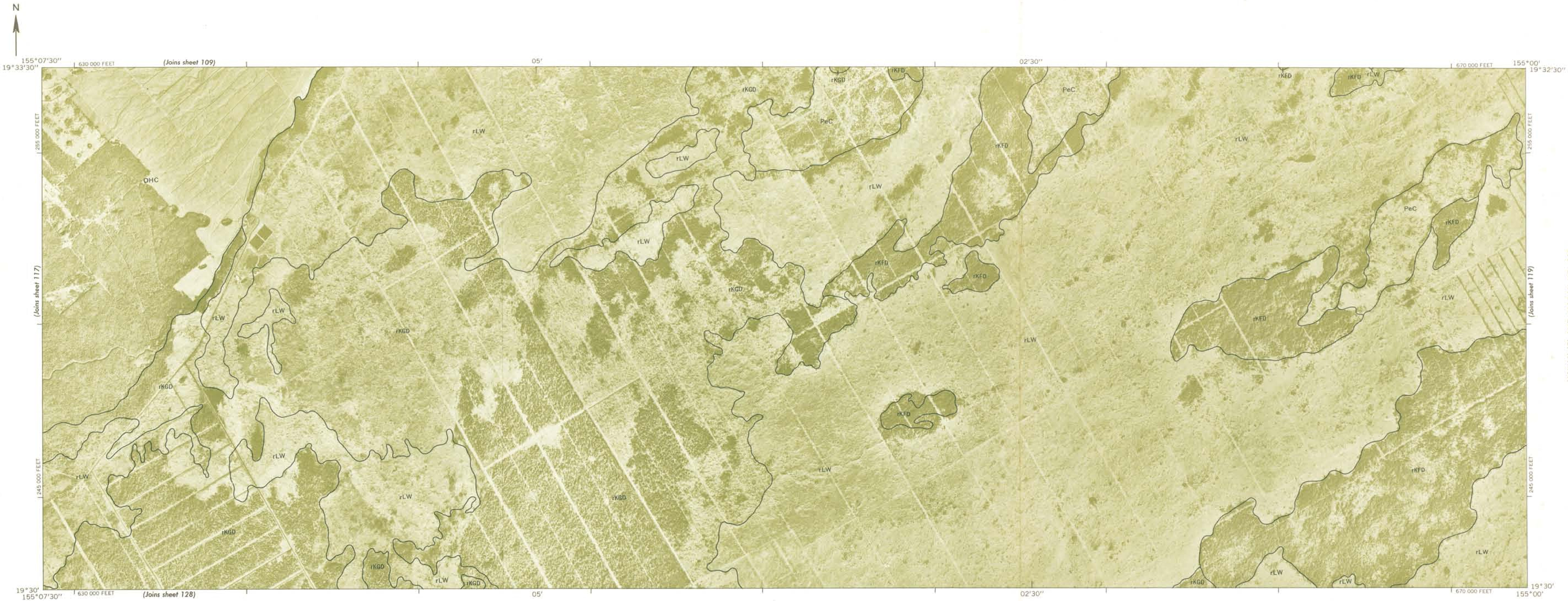
Photobase from 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 1. Old Hawaiian datum.

Scale 1:24 000

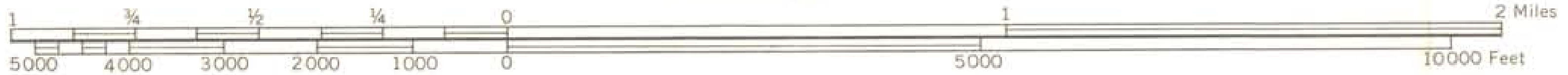
1 ¾ ½ ¼ 0 1 2 Miles

5000 4000 3000 2000 1000 0 5000 10000 Feet

HAWAII ISLAND, HAWAII — SHEET NUMBER 118



Scale 1:24 000



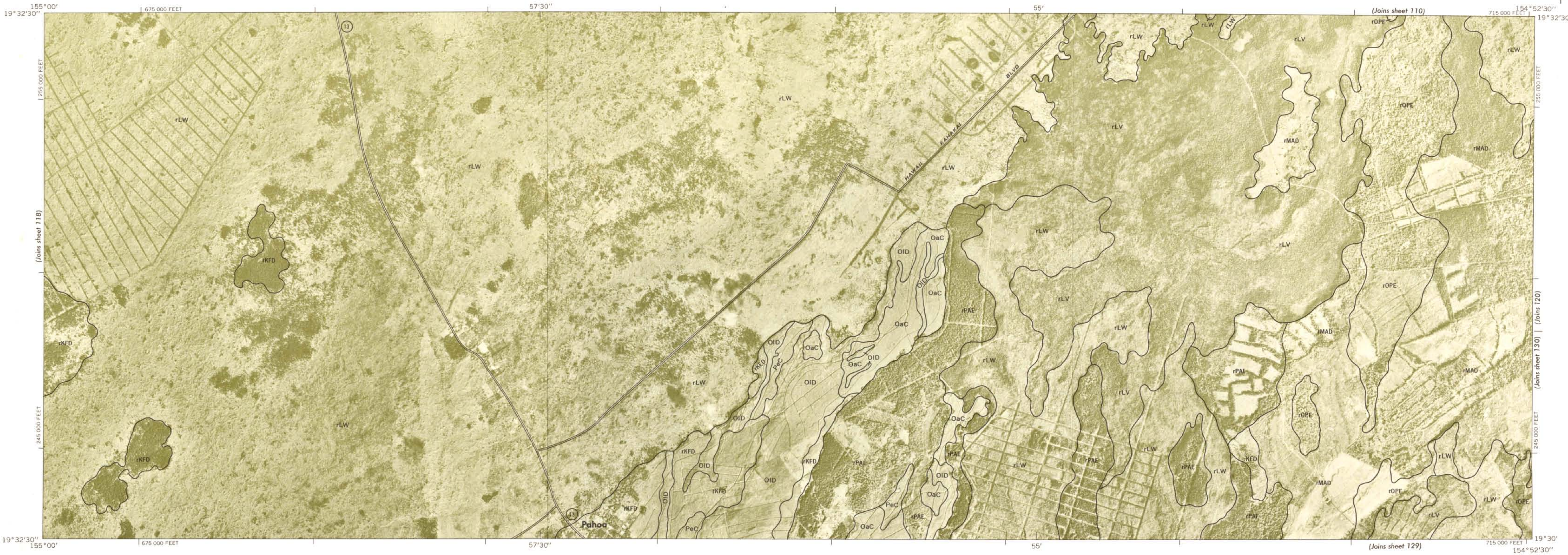
Photobase from 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 1. Old Hawaiian datum.

HAWAII ISLAND, HAWAII NO. 118

This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the University of Hawaii Agricultural Experiment Station.

119

N



This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the University of Hawaii Agricultural Experiment Station.

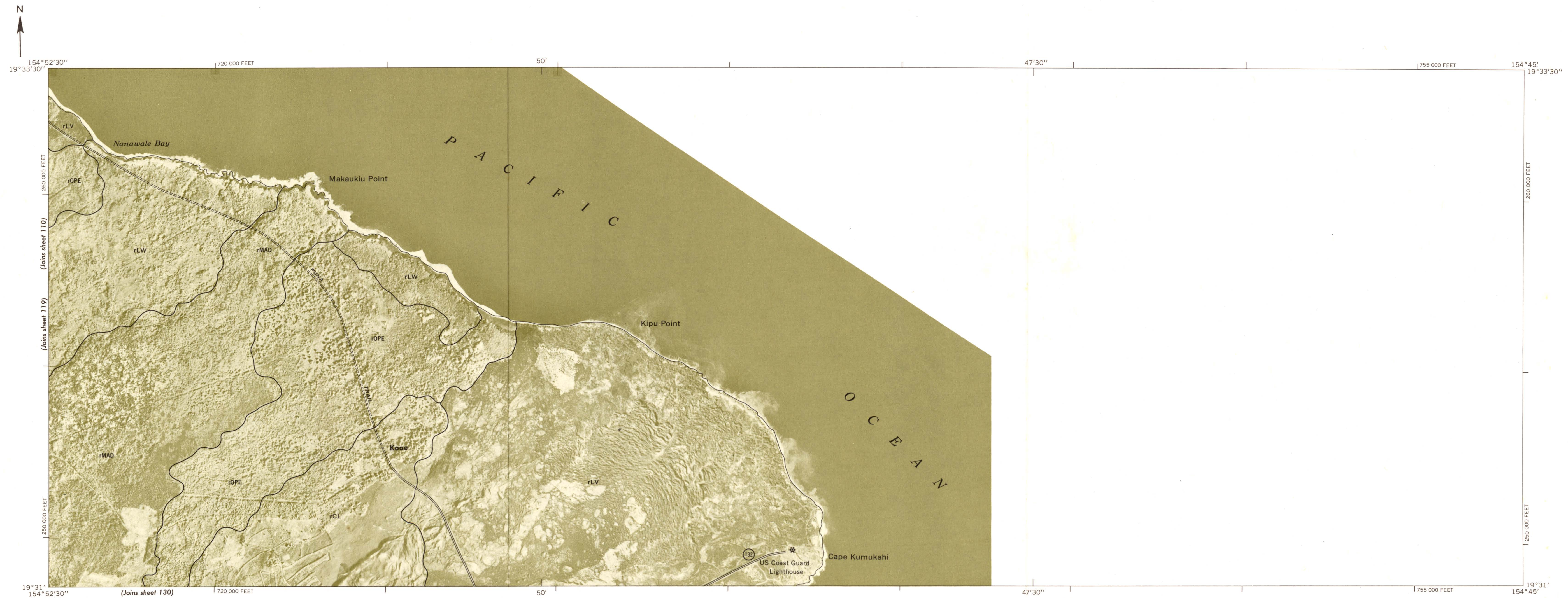
HAWAII ISLAND, HAWAII NO. 119

Photobase from 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 1. Old Hawaiian datum.

Scale 1:24 000

1 ¾ ½ ¼ 0 1 2 Miles

5000 4000 3000 2000 1000 0 5000 10000 Feet



Scale 1:24 000

1 ¾ ½ ¼ 0 1 2 Miles

5000 4000 3000 2000 1000 0 5000 10000 Feet

Photobase from 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 1. Old Hawaiian datum.

HAWAII ISLAND, HAWAII NO. 120

This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the University of Hawaii Agricultural Experiment Station.

This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the University of Hawaii Agricultural Experiment Station.

HAWAII ISLAND, HAWAII NO. 121

Photobase from 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 1. Old Hawaiian datum.

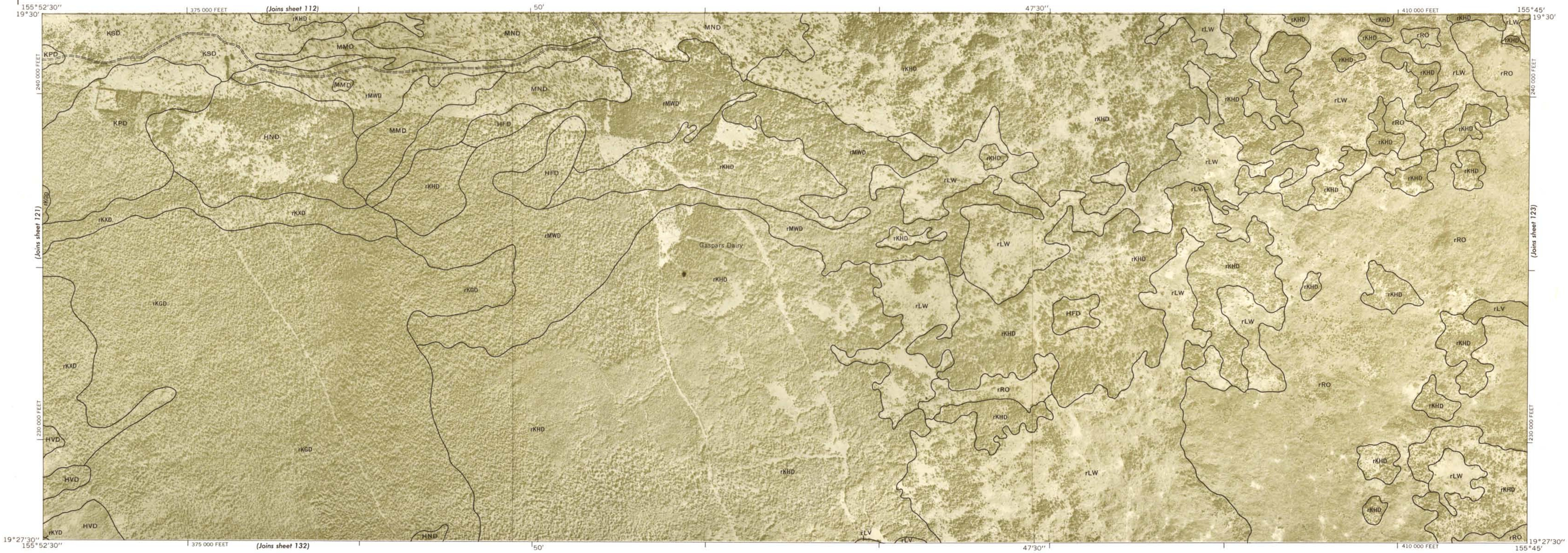
Scale 1:24 000

1 ¾ ½ ¼ 0 1 2 Miles

5000 4000 3000 2000 1000 0 5000 10000 Feet

HAWAII ISLAND, HAWAII — SHEET NUMBER 122

N



Scale 1:24 000

1 ¾ ½ ¼ 0 1 2 Miles

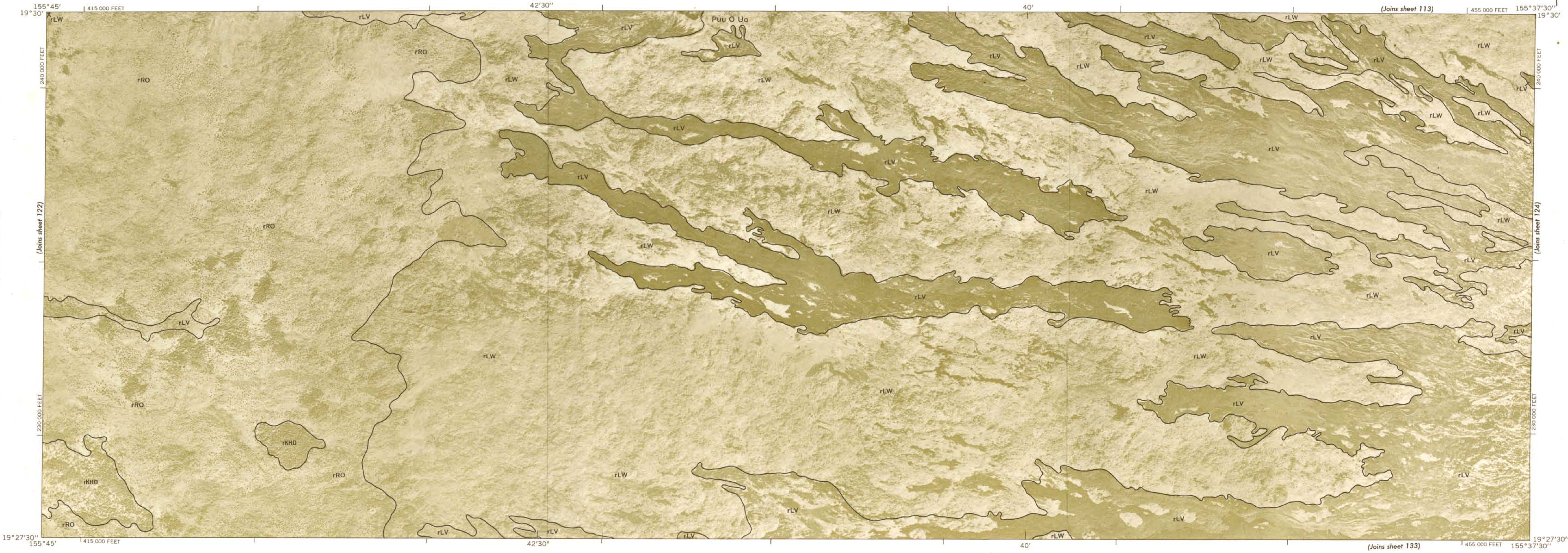
5000 4000 3000 2000 1000 0 5000 10000 Feet

Photobase from 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 1. Old Hawaiian datum.

HAWAII ISLAND, HAWAII NO. 122

This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the University of Hawaii Agricultural Experiment Station.

N



This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the University of Hawaii Agricultural Experiment Station.

HAWAII ISLAND, HAWAII NO. 123

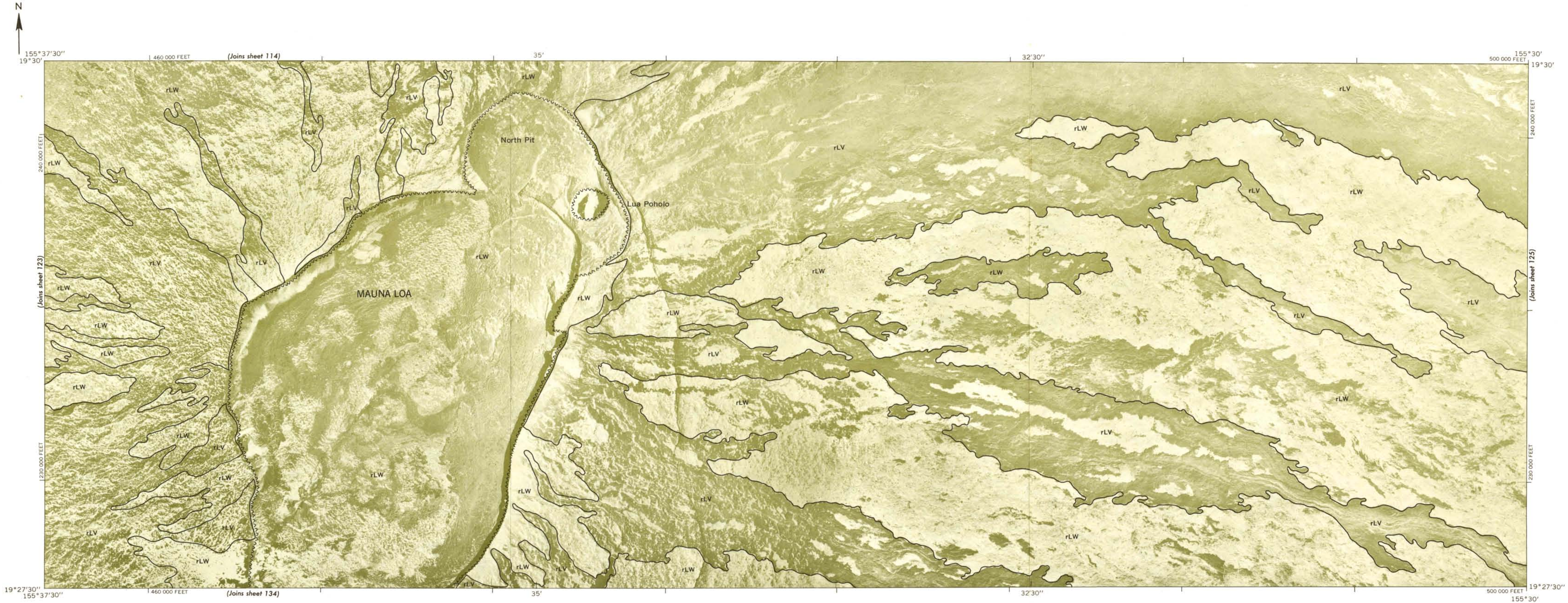
Photobase from 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 1. Old Hawaiian datum.

Scale 1:24 000

1 ¾ ½ ¼ 0 1 2 Miles

5000 4000 3000 2000 1000 0 5000 10000 Feet

(124)



Scale 1:24 000

1 ¾ ½ ¼ 0 1 2 Miles

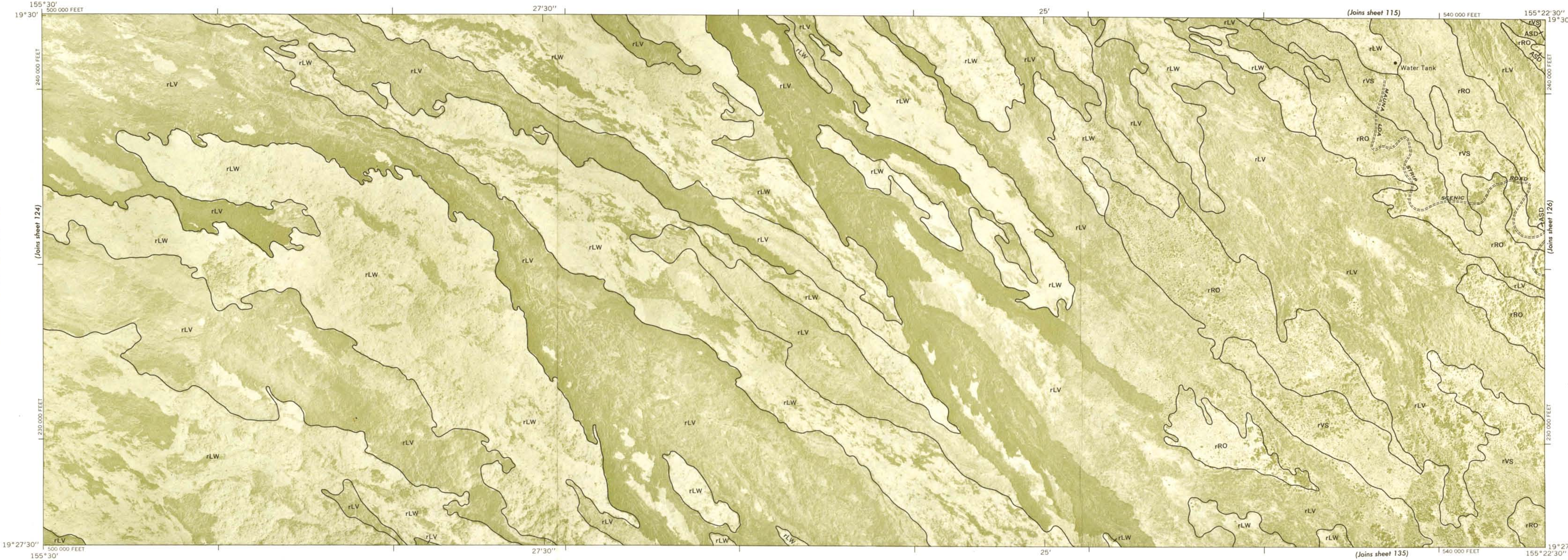
5000 4000 3000 2000 1000 0 5000 10000 Feet

Photobase from 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 1. Old Hawaiian datum.

HAWAII ISLAND, HAWAII NO. 124

This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the University of Hawaii Agricultural Experiment Station.

N



HAWAII ISLAND, HAWAII NO. 125

...as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the University of Hawaii Agricultural Experiment Station.

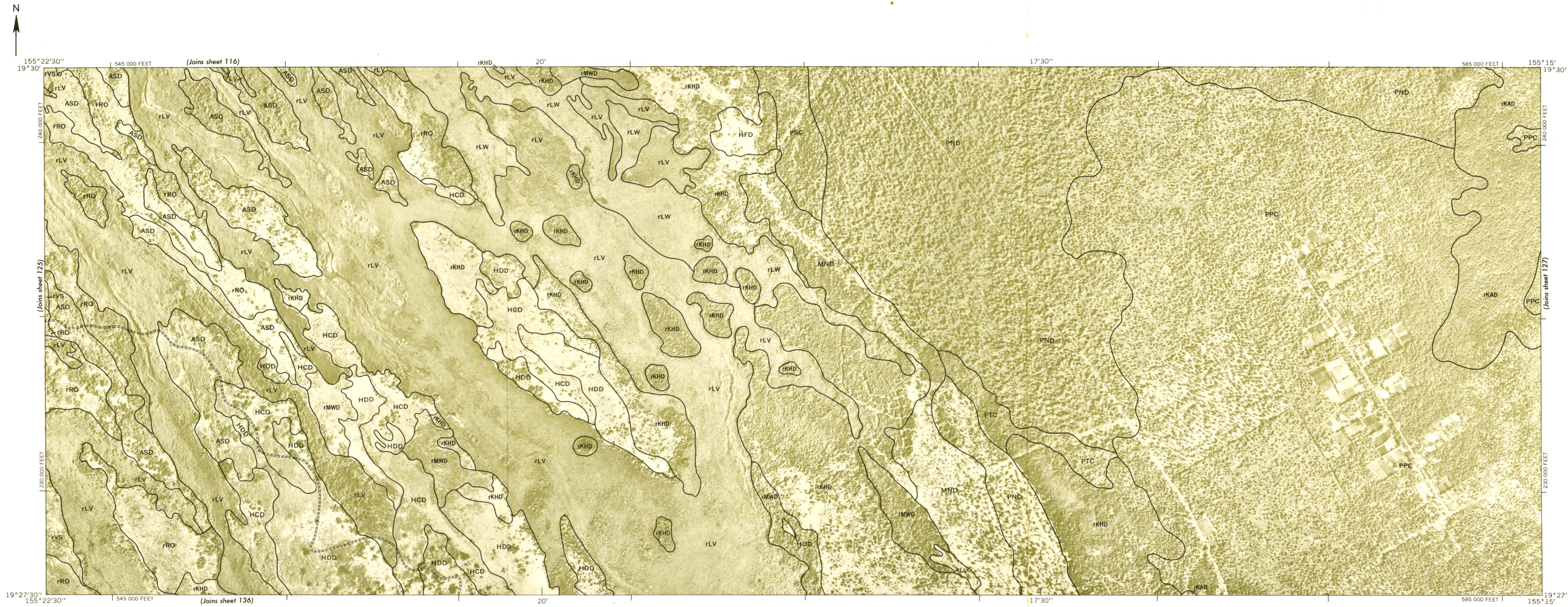
Photobase from 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 1. Old Hawaiian datum.

Scale 1:24 000

1 ¾ ½ ¼ 0 1 2 Miles

5000 4000 3000 2000 1000 0 5000 10000 Feet

HAWAII ISLAND, HAWAII — SHEET NUMBER 126



Scale 1:24 000

1 ¾ ½ ¼ 0 1 2 Miles

5000 4000 3000 2000 1000 0 5000 10000 Feet

Photobase from 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 1. Old Hawaiian datum.

This map is one ... compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the University of Hawaii Agricultural Experiment Station.

HAWAII ISLAND, HAWAII NO. 126

127

This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the University of Hawaii Agricultural Experiment Station.

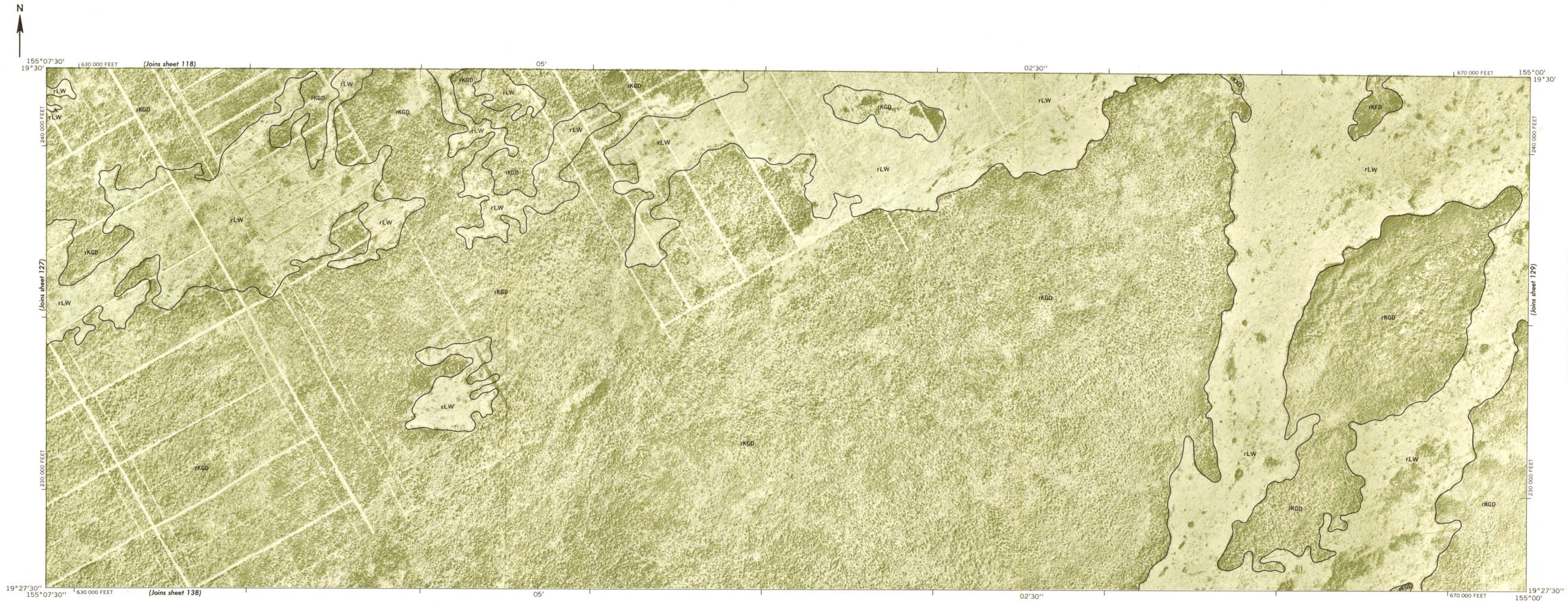
HAWAII ISLAND, HAWAII NO. 127

Photobase from 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 1. Old Hawaiian datum.

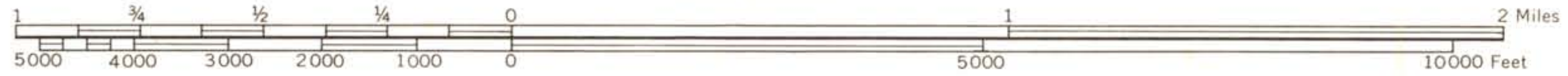
Scale 1:24 000

1 ¾ ½ ¼ 0 1 2 Miles

5000 4000 3000 2000 1000 0 5000 10000 Feet



Scale 1:24 000



Photobase from 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 1. Old Hawaiian datum.

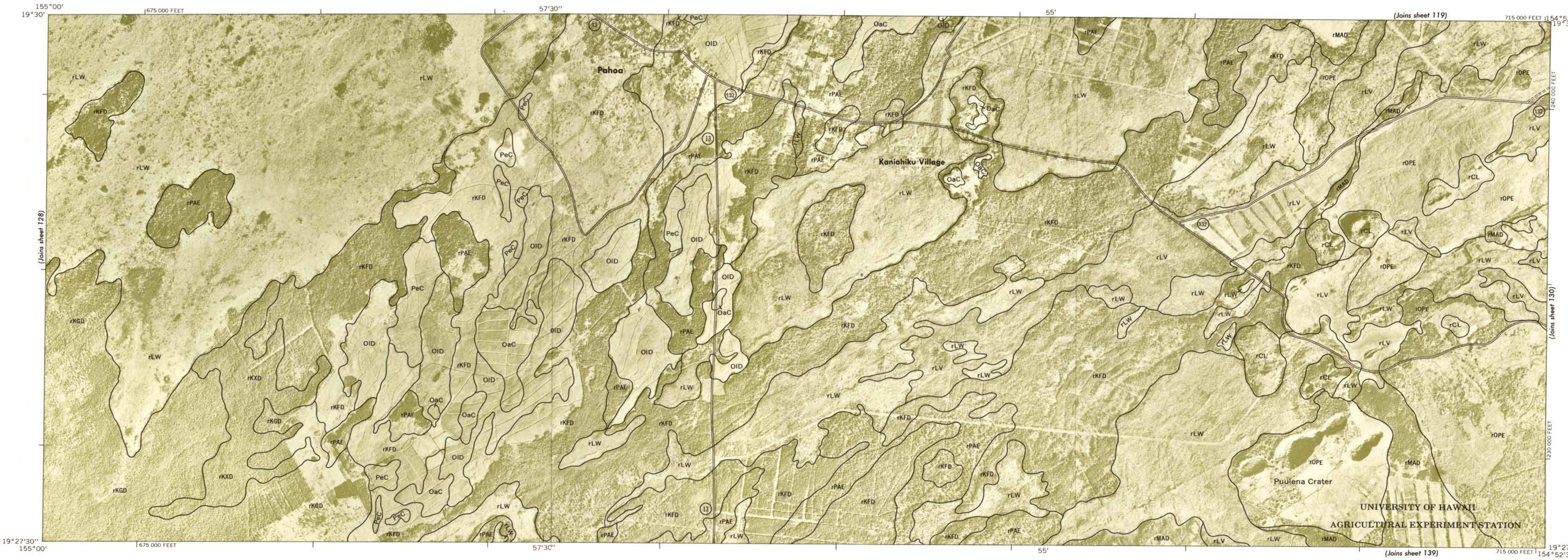
HAWAII ISLAND, HAWAII NO. 128

This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the University of Hawaii Agricultural Experiment Station.

129

This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the University of Hawaii Agricultural Experiment Station.

HAWAII ISLAND, HAWAII NO. 129



Photobase from 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 1. Old Hawaiian datum.

Scale 1:24 000

1 ¾ ½ ¼ 0 1 2 Miles

5000 4000 3000 2000 1000 0 5000 10000 Feet

HAWAII ISLAND, HAWAII — SHEET NUMBER 130

N

Scale 1:24 000

1 ¾ ½ ¼ 0 1 2 Miles

5000 4000 3000 2000 1000 0 5000 10000 Feet

Photobase from 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 1. Old Hawaiian datum.

This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the University of Hawaii Agricultural Experiment Station.

N

This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the University of Hawaii Agricultural Experiment Station.

HAWAII ISLAND, HAWAII NO. 131

Photobase from 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 1. Old Hawaiian datum.

Scale 1:24 000

1 ¾ ½ ¼ 0 1 2 Miles

5000 4000 3000 2000 1000 0 5000 10000 Feet

HAWAII ISLAND, HAWAII — SHEET NUMBER 132

N

155°52'30" 375 000 FEET (Joins sheet 122) 50' 47'30" 410 000 FEET 155°45'

19°27'30" 19°27'30"

19°25' 19°25'

155°52'30" 375 000 FEET (Joins sheet 140) 50' 47'30" 410 000 FEET 155°45'

Scale 1:24 000

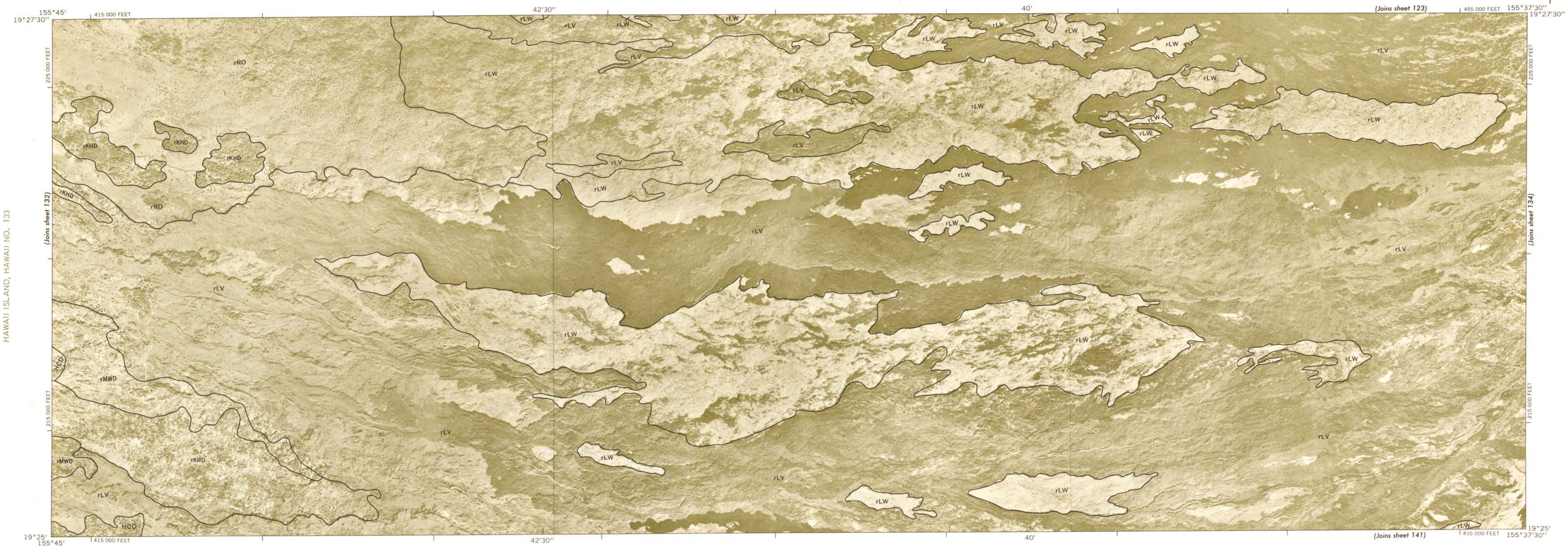
1 ¾ ½ ¼ 0 1 2 Miles

5000 4000 3000 2000 1000 0 5000 10000 Feet

Photobase from 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 1. Old Hawaiian datum.

This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the University of Hawaii Agricultural Experiment Station.

N



This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the University of Hawaii Agricultural Experiment Station.

HAWAII ISLAND, HAWAII NO. 133

Photobase from 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 1. Old Hawaiian datum.

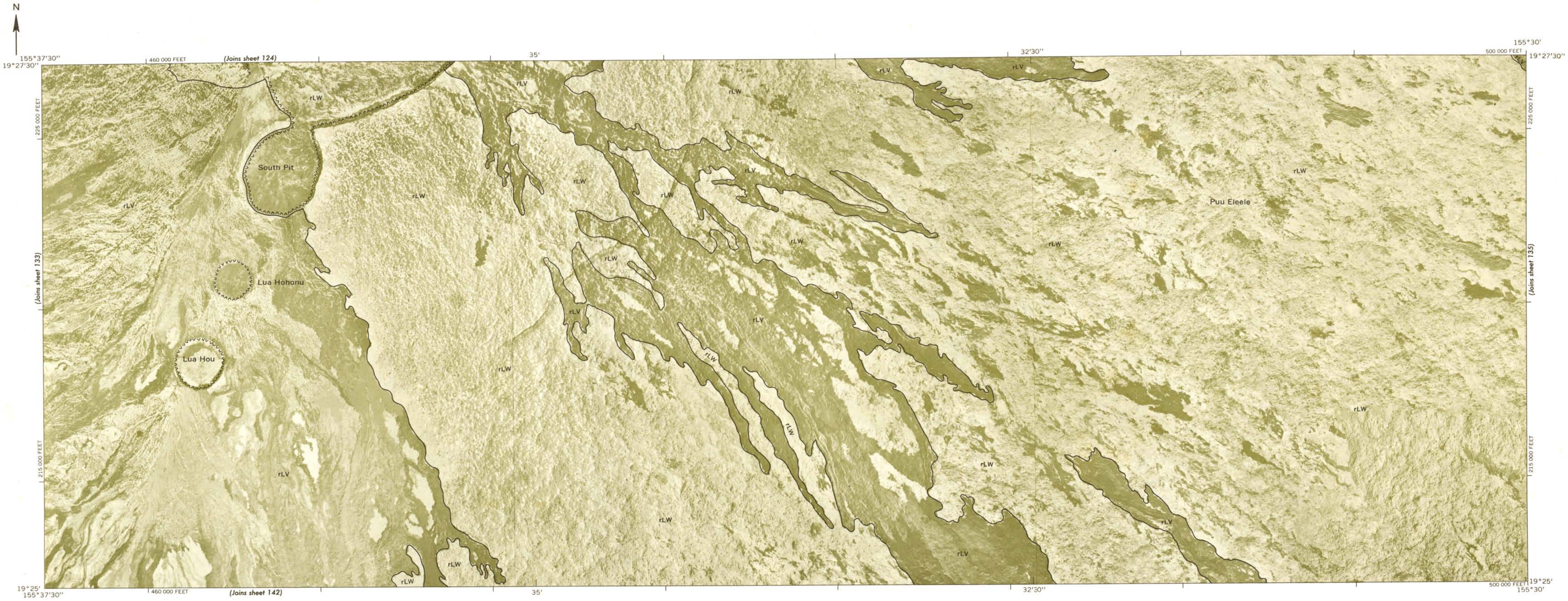
Scale 1:24 000

1 ¾ ½ ¼ 0 1 2 Miles

5000 4000 3000 2000 1000 0 5000 10000 Feet

134

HAWAII ISLAND, HAWAII — SHEET NUMBER 134



Scale 1:24 000

1 ¾ ½ ¼ 0 1 2 Miles

5000 4000 3000 2000 1000 0 5000 10000 Feet

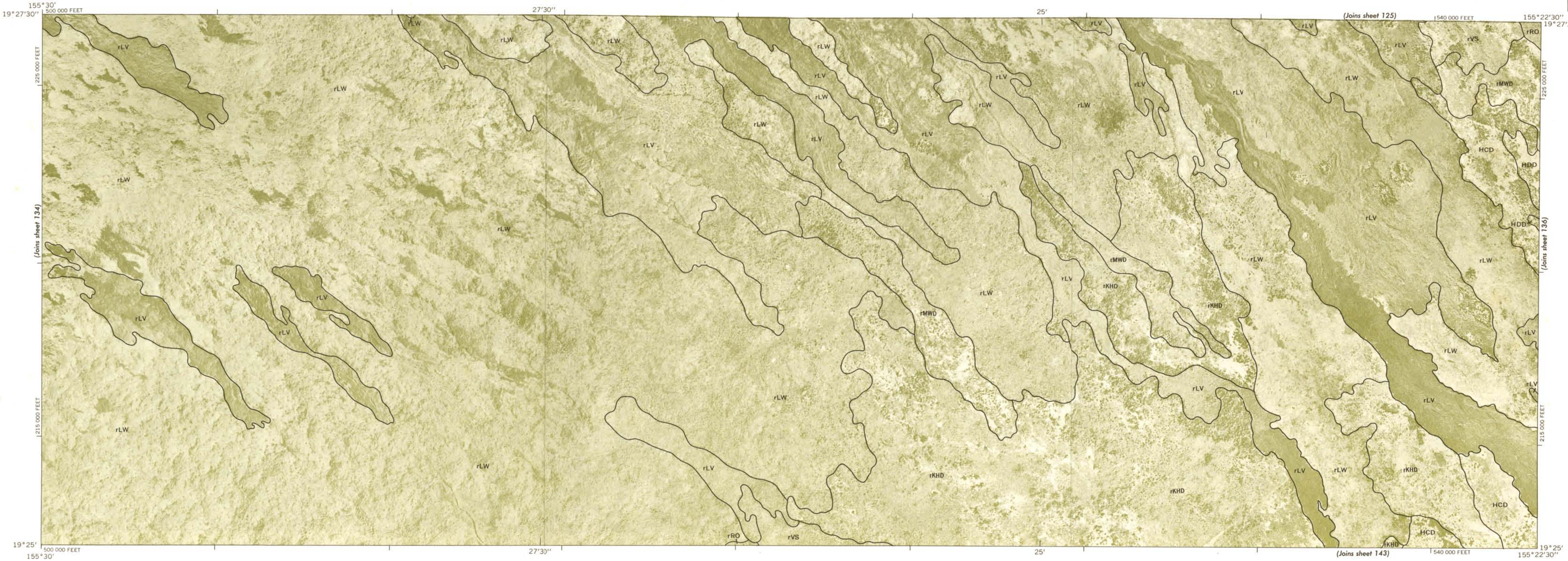
Photobase from 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 1. Old Hawaiian datum.

HAWAII ISLAND, HAWAII NO. 134

This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the University of Hawaii Agricultural Experiment Station.

135

N



This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the University of Hawaii Agricultural Experiment Station.

HAWAII ISLAND, HAWAII NO. 135

Photobase from 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 1. Old Hawaiian datum.

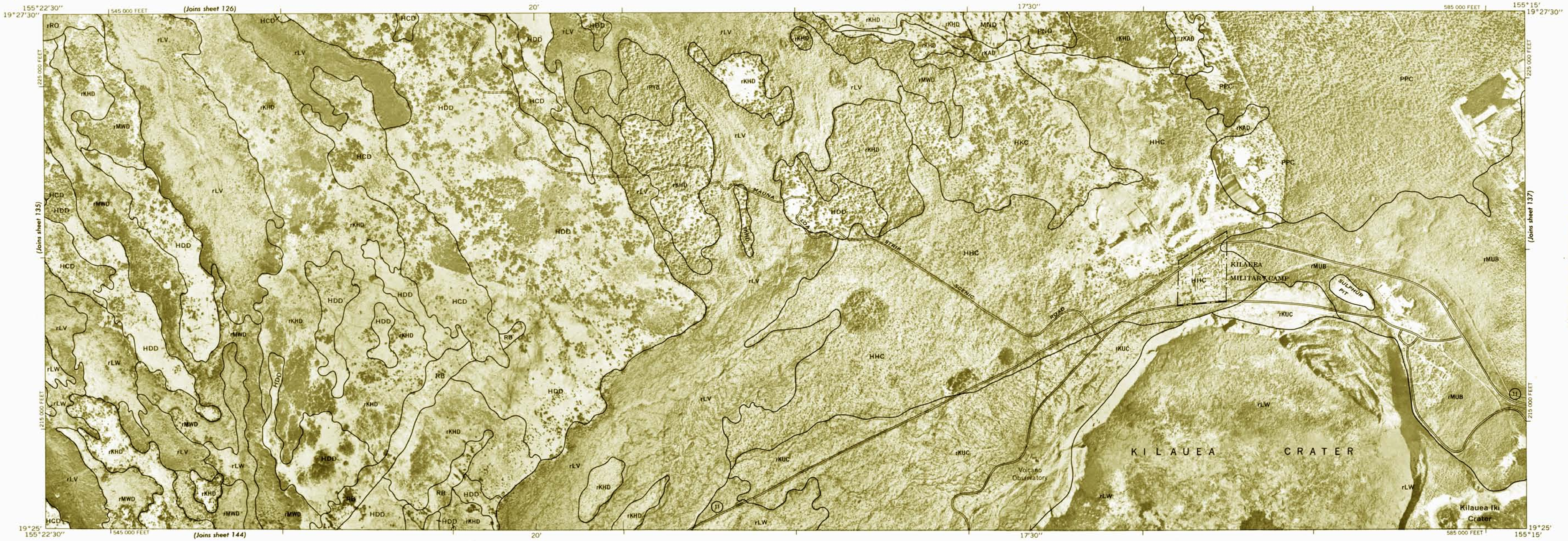
Scale 1:24 000

1 ¾ ½ ¼ 0 1 2 Miles

5000 4000 3000 2000 1000 0 5000 10000 Feet

HAWAII ISLAND, HAWAII — SHEET NUMBER 136

N



Scale 1:24 000

1 ¾ ½ ¼ 0 1 2 Miles

5000 4000 3000 2000 1000 0 5000 10000 Feet

Photobase from 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 1, Old Hawaiian datum.

HAWAII ISLAND, HAWAII NO. 136

This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the University of Hawaii Agricultural Experiment Station.

This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the University of Hawaii Agricultural Experiment Station.

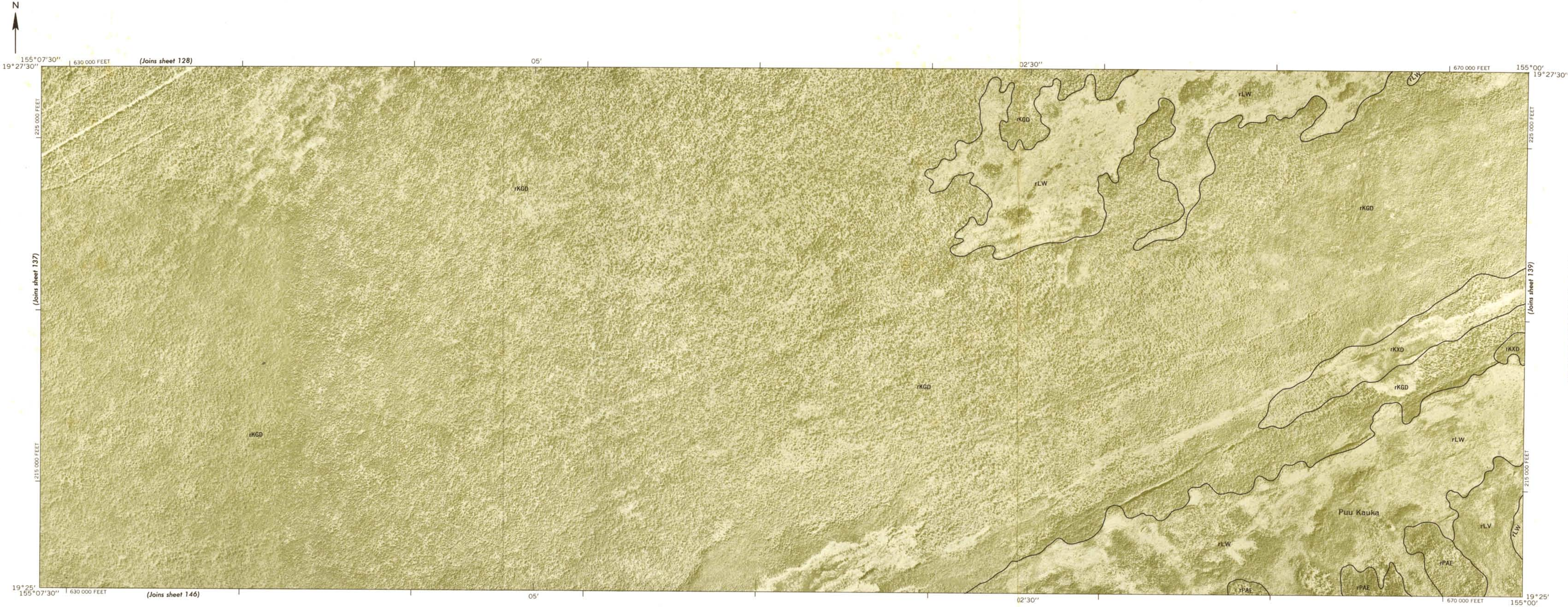
HAWAII ISLAND, HAWAII NO. 137

Photobase from 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 1. Old Hawaiian datum.

Scale 1:24 000

1 ¾ ½ ¼ 0 1 2 Miles

5000 4000 3000 2000 1000 0 5000 10000 Feet



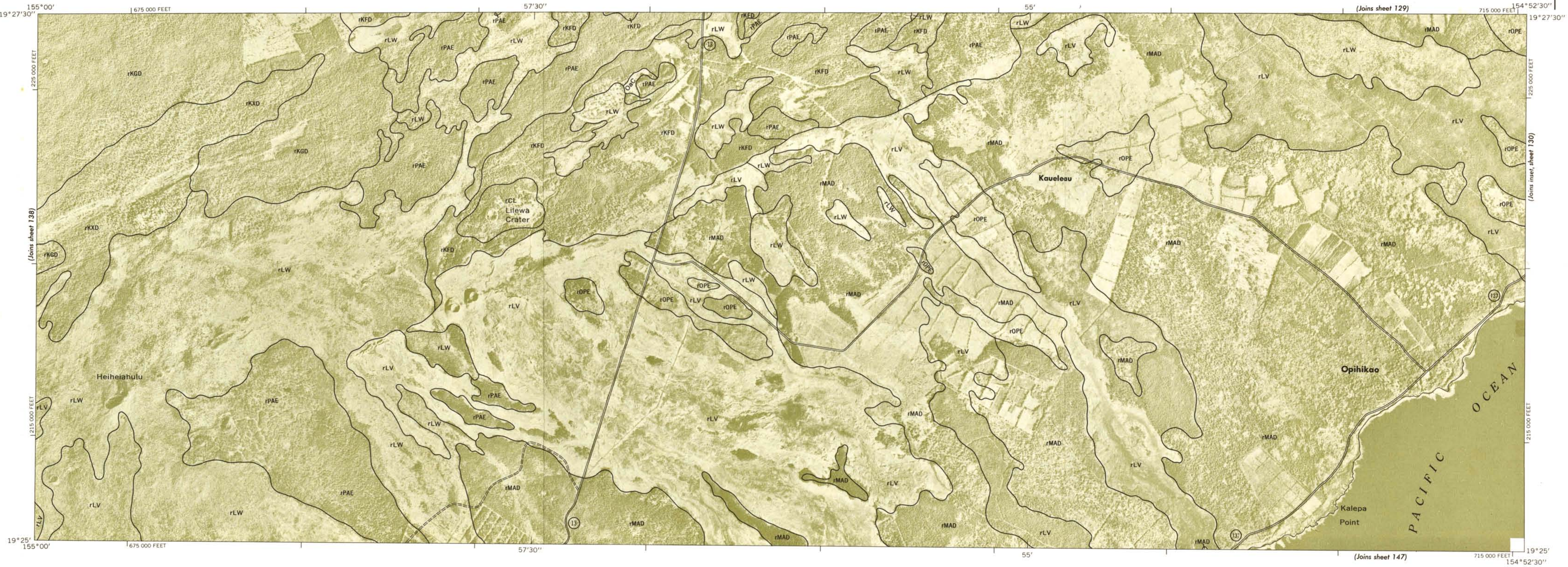
Scale 1:24 000

Photobase from 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 1. Old Hawaiian datum.

HAWAII ISLAND, HAWAII NO. 138

This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the University of Hawaii Agricultural Experiment Station.

139



This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the University of Hawaii Agricultural Experiment Station.

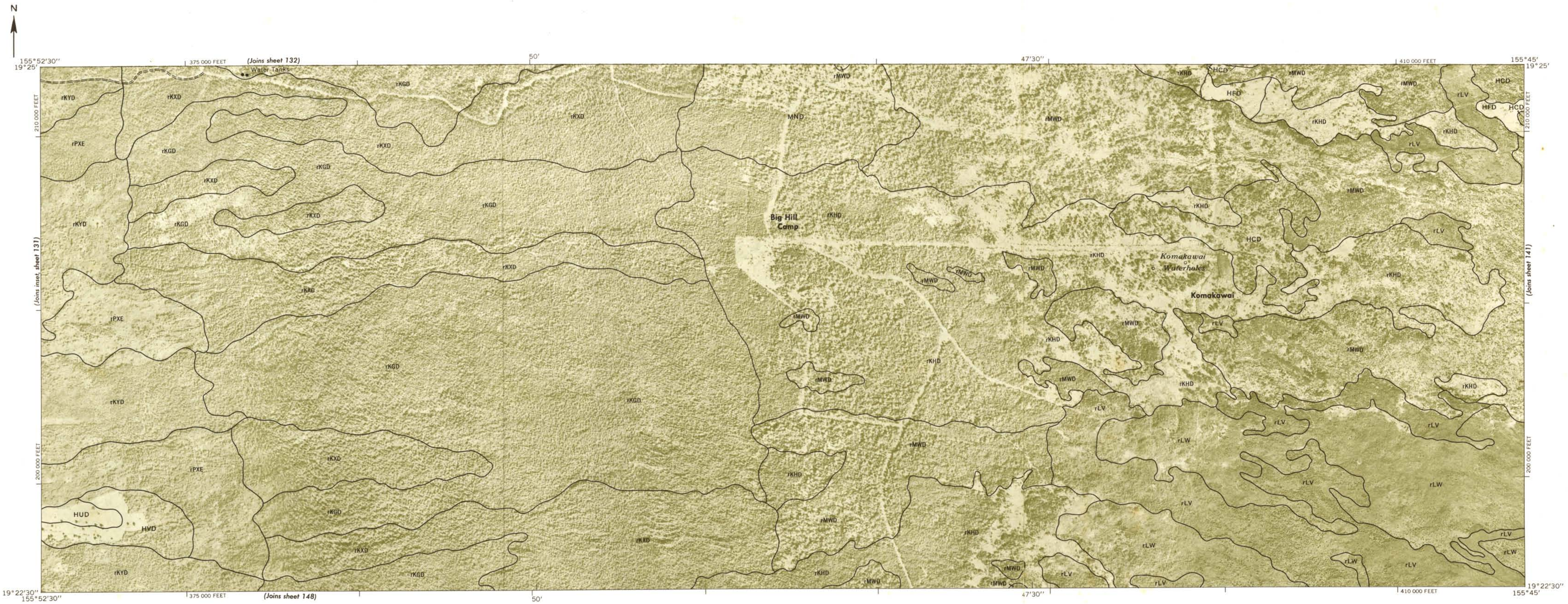
HAWAII ISLAND, HAWAII NO. 139

Photobase from 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 1. Old Hawaiian datum.

Scale 1:24 000

1 ¾ ½ ¼ 0 1 2 Miles

5000 4000 3000 2000 1000 0 5000 10000 Feet



Scale 1:24 000

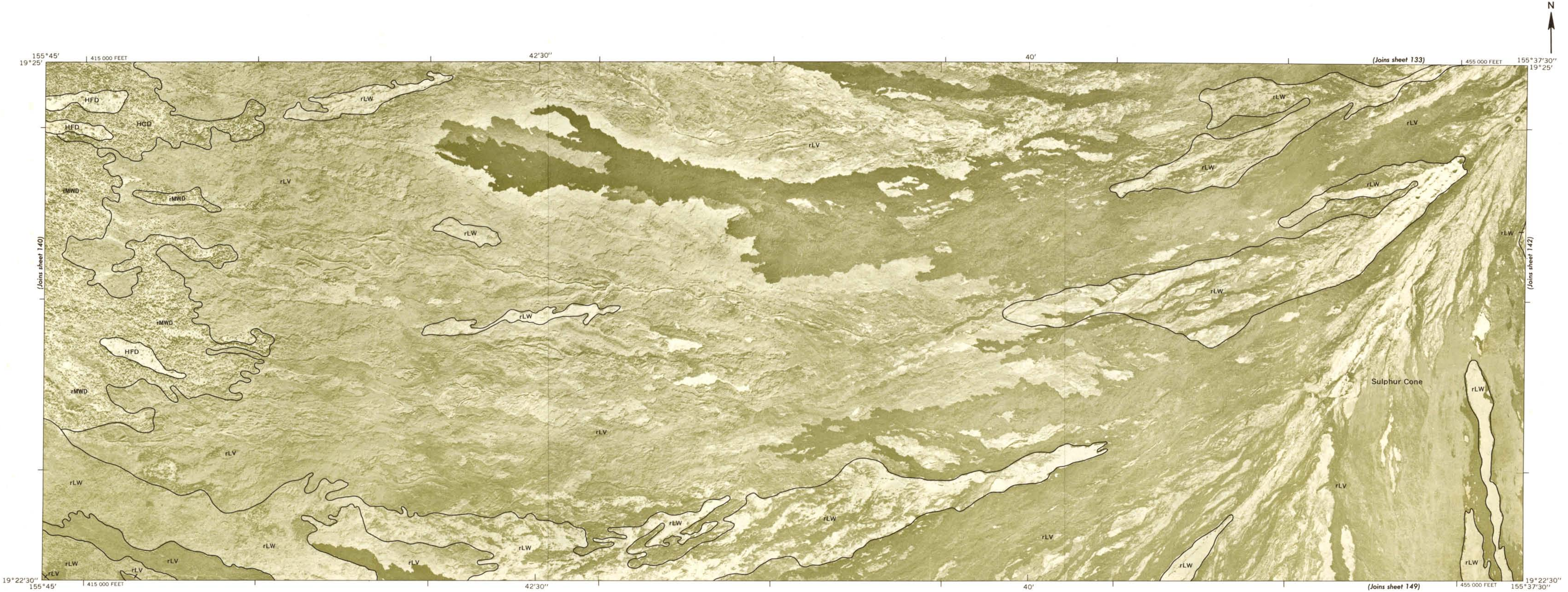
1 ¾ ½ ¼ 0 1 2 Miles

5000 4000 3000 2000 1000 0 5000 10000 Feet

Photobase from 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 1. Old Hawaiian datum.

HAWAII ISLAND, HAWAII NO. 140

This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the University of Hawaii Agricultural Experiment Station.



This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the University of Hawaii Agricultural Experiment Station.

HAWAII ISLAND, HAWAII NO. 141

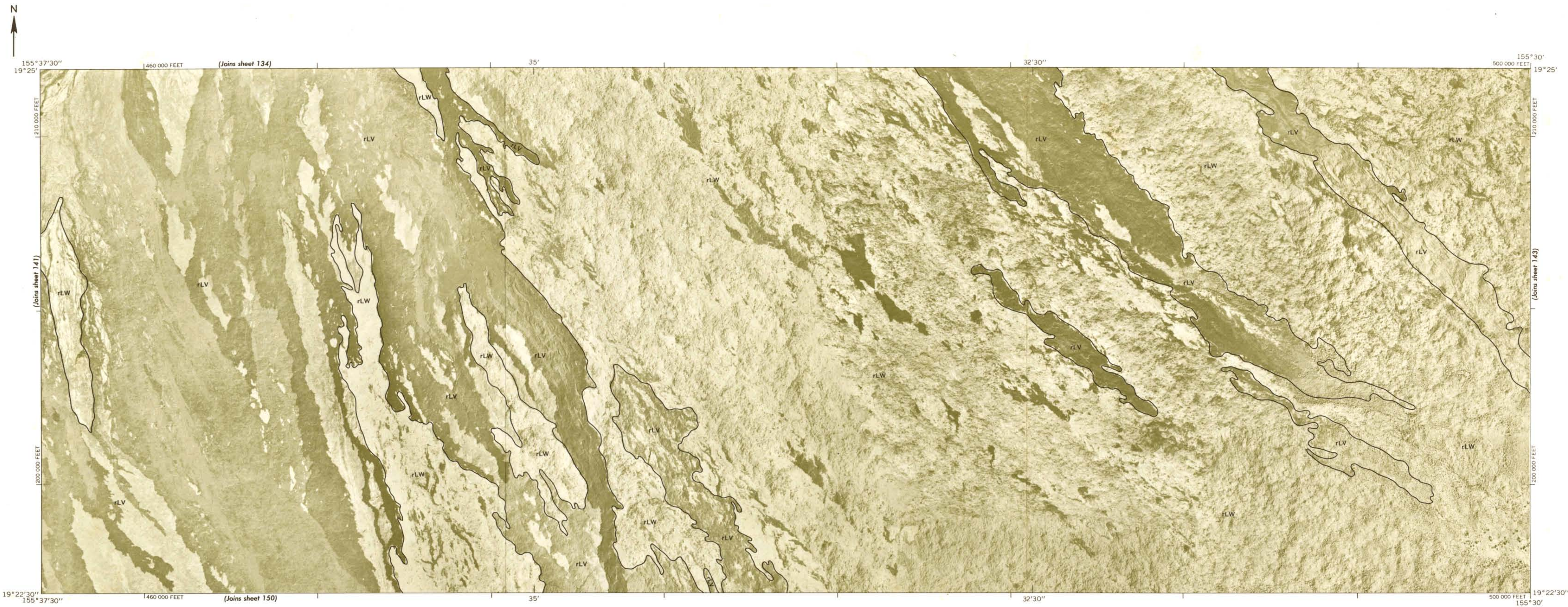
Photobase from 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 1. Old Hawaiian datum.

Scale 1:24 000

1 ¾ ½ ¼ 0 1 2 Miles

5000 4000 3000 2000 1000 0 5000 10000 Feet

HAWAII ISLAND, HAWAII — SHEET NUMBER 142



Scale 1:24 000

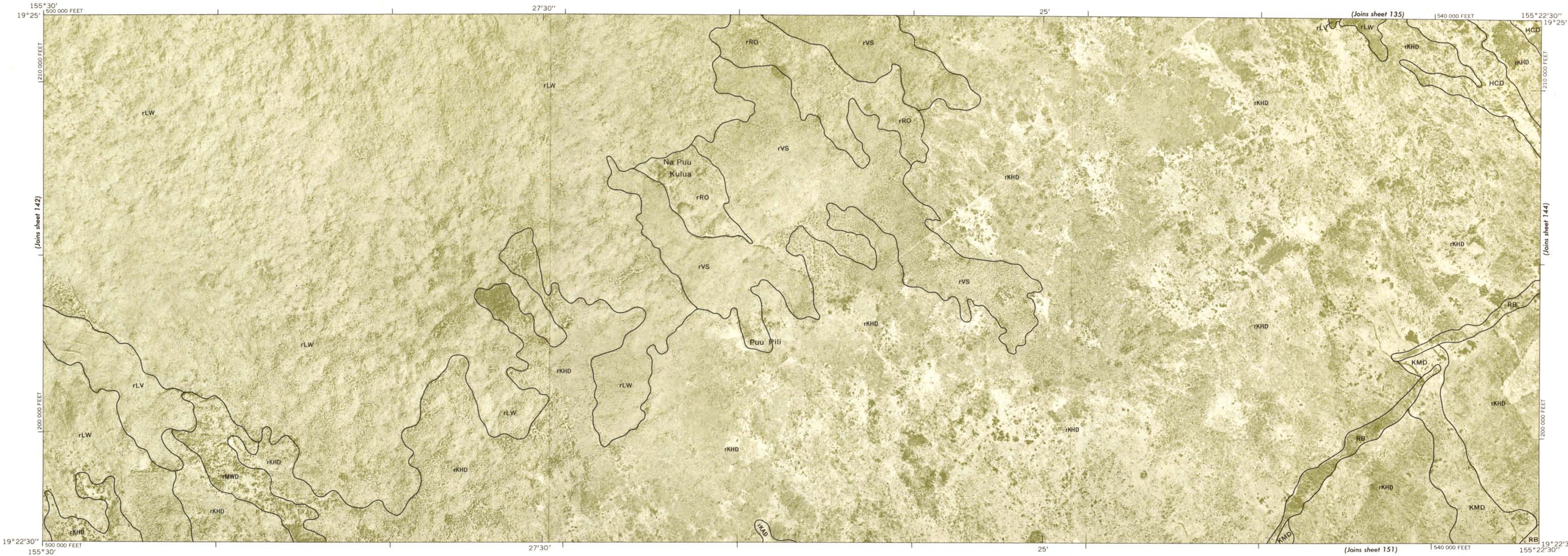
1	¾	½	¼	0		1		2 Miles
5000	4000	3000	2000	1000	0	5000		10000 Feet

Photobase from 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 1, Old Hawaiian datum.

HAWAII ISLAND, HAWAII NO. 142

This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the University of Hawaii Agricultural Experiment Station.

N



This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the University of Hawaii Agricultural Experiment Station.

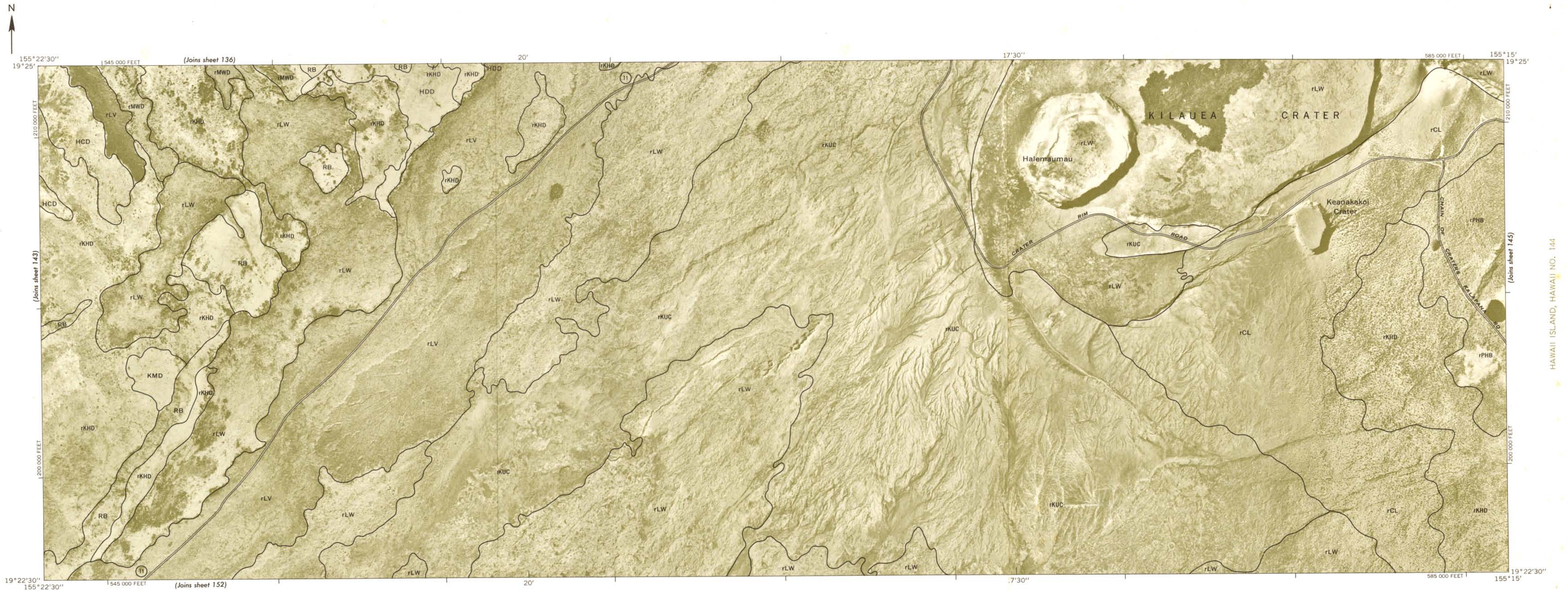
Photobase from 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 1. Old Hawaiian datum.

Scale 1:24 000

1 ¾ ½ ¼ 0 1 2 Miles

5000 4000 3000 2000 1000 0 5000 10000 Feet

HAWAII ISLAND, HAWAII — SHEET NUMBER 144



Scale 1:24 000

1 ¾ ½ ¼ 0 1 2 Miles

5000 4000 3000 2000 1000 0 5000 10000 Feet

Photobase from 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 1. Old Hawaiian datum.

HAWAII ISLAND, HAWAII NO. 144

This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the University of Hawaii Agricultural Experiment Station.

This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the University of Hawaii Agricultural Experiment Station.

HAWAII ISLAND, HAWAII NO. 145

Photobase from 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 1. Old Hawaiian datum.

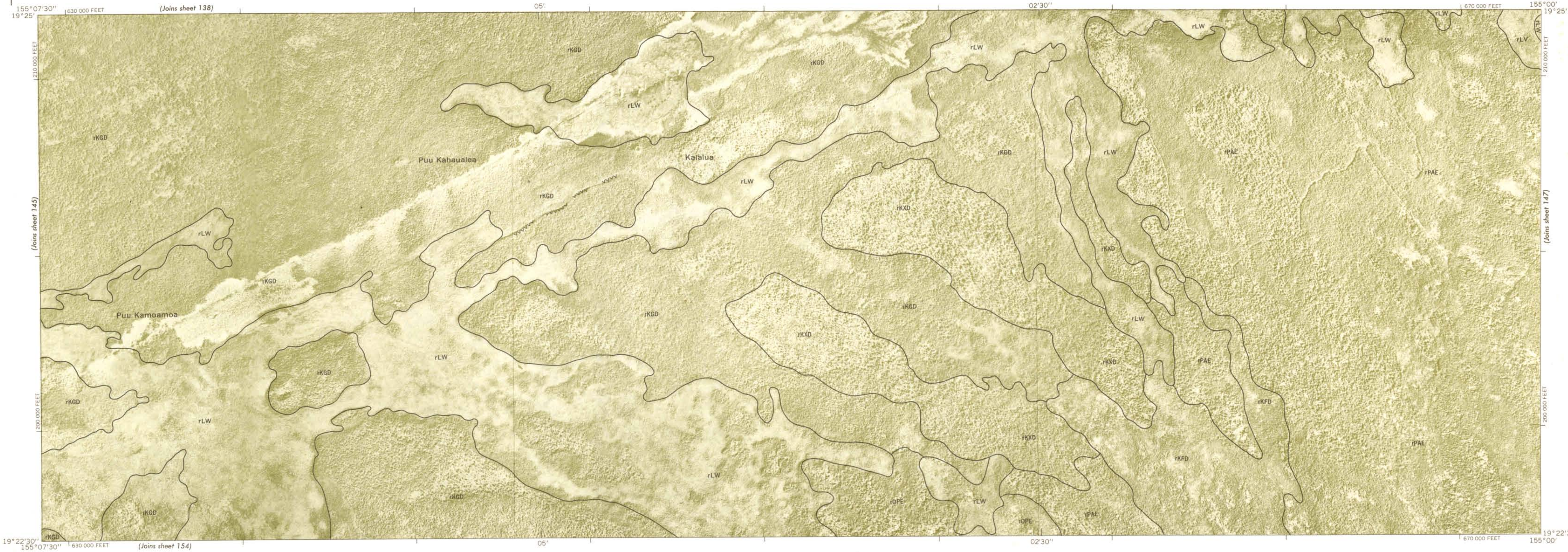
Scale 1:24 000

1 ¾ ½ ¼ 0 1 2 Miles

5000 4000 3000 2000 1000 0 5000 10000 Feet

HAWAII ISLAND HAWAII — SHEET NUMBER 146

N



This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the University of Hawaii Agricultural Experiment Station.

Scale 1:24 000

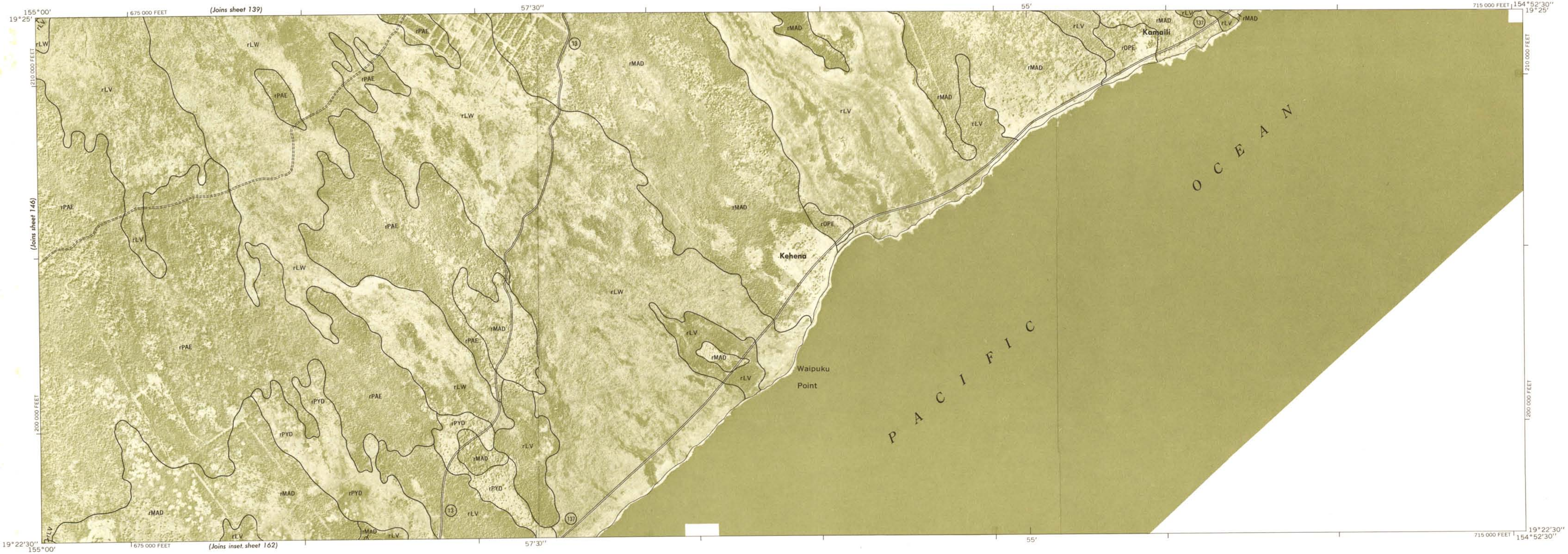
1 ¾ ½ ¼ 0 1 2 Miles

5000 4000 3000 2000 1000 0 5000 10000 Feet

Photobase from 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 1. Old Hawaiian datum.

This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the University of Hawaii Agricultural Experiment Station.

HAWAII ISLAND, HAWAII NO. 147



Photobase from 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 1. Old Hawaiian datum.

Scale 1:24 000

1 ¾ ½ ¼ 0 1 2 Miles

5000 4000 3000 2000 1000 0 5000 10000 Feet

Scale 1:24 000

1 ¾ ½ ¼ 0 1 2 Miles

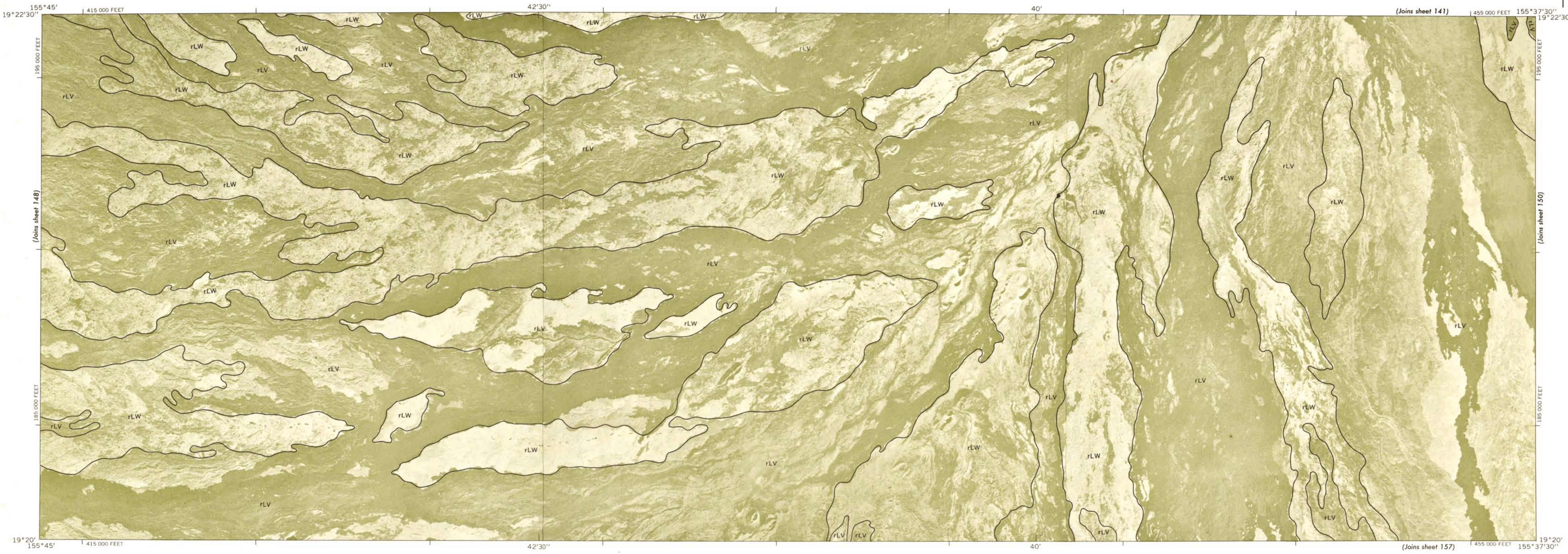
5000 4000 3000 2000 1000 0 5000 10000 Feet

Photobase from 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 1. Old Hawaiian datum.

HAWAII ISLAND, HAWAII NO. 148

This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the University of Hawaii Agricultural Experiment Station.

N



This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the University of Hawaii Agricultural Experiment Station.

HAWAII ISLAND, HAWAII NO. 149

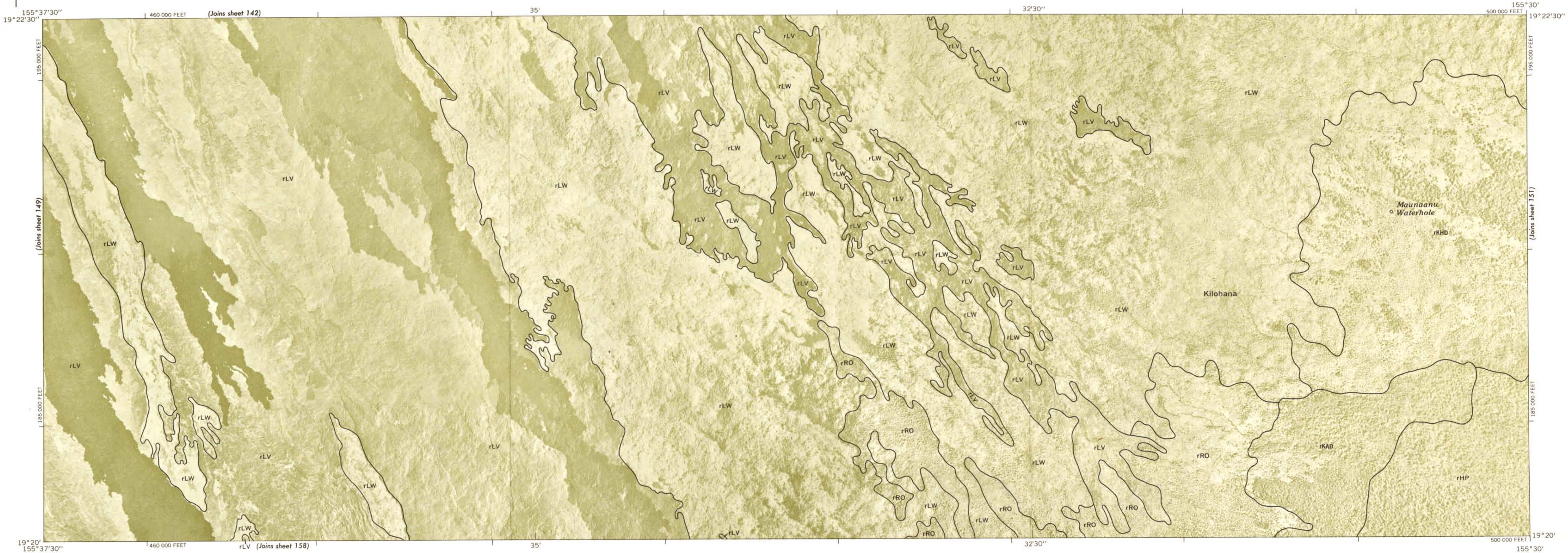
Photobase from 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 1. Old Hawaiian datum.

Scale 1:24 000

1 ¾ ½ ¼ 0 1 2 Miles

5000 4000 3000 2000 1000 0 5000 10000 Feet

N



Scale 1:24 000

1 ¾ ½ ¼ 0 1 2 Miles

5000 4000 3000 2000 1000 0 5000 10000 Feet

Photobase from 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 1. Old Hawaiian datum.

This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the University of Hawaii Agricultural Experiment Station.

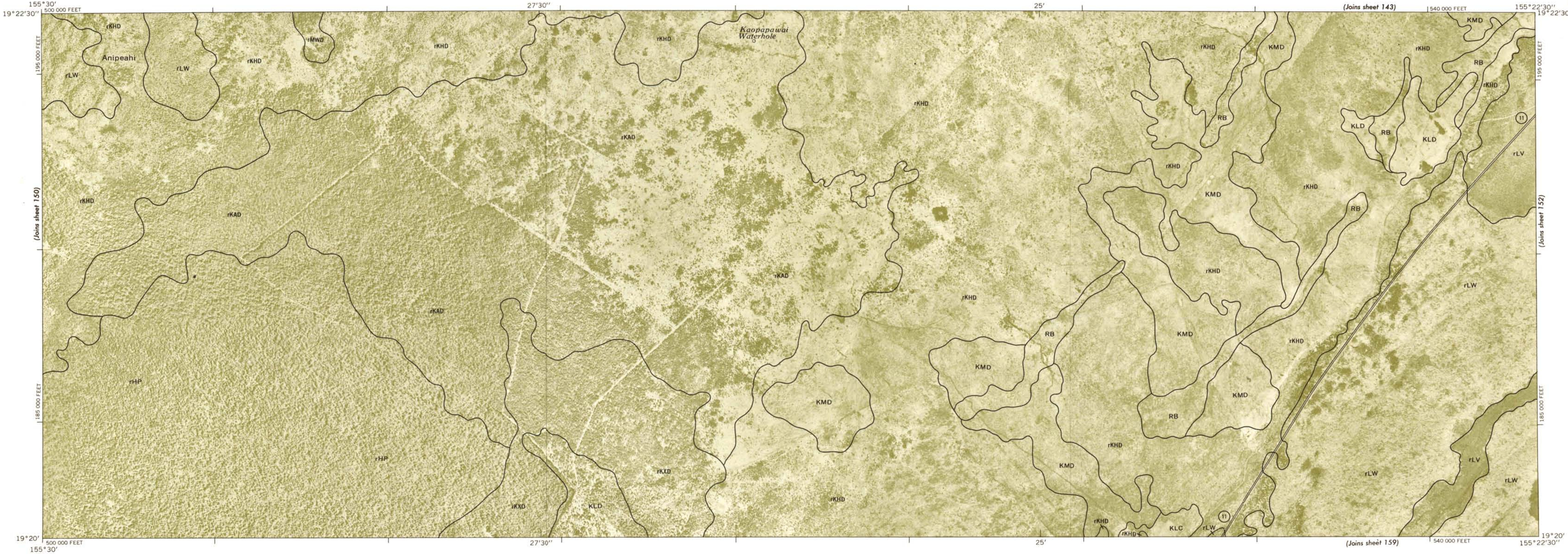
HAWAII ISLAND, HAWAII NO. 150

151

N

This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the University of Hawaii Agricultural Experiment Station.

HAWAII ISLAND, HAWAII NO. 151

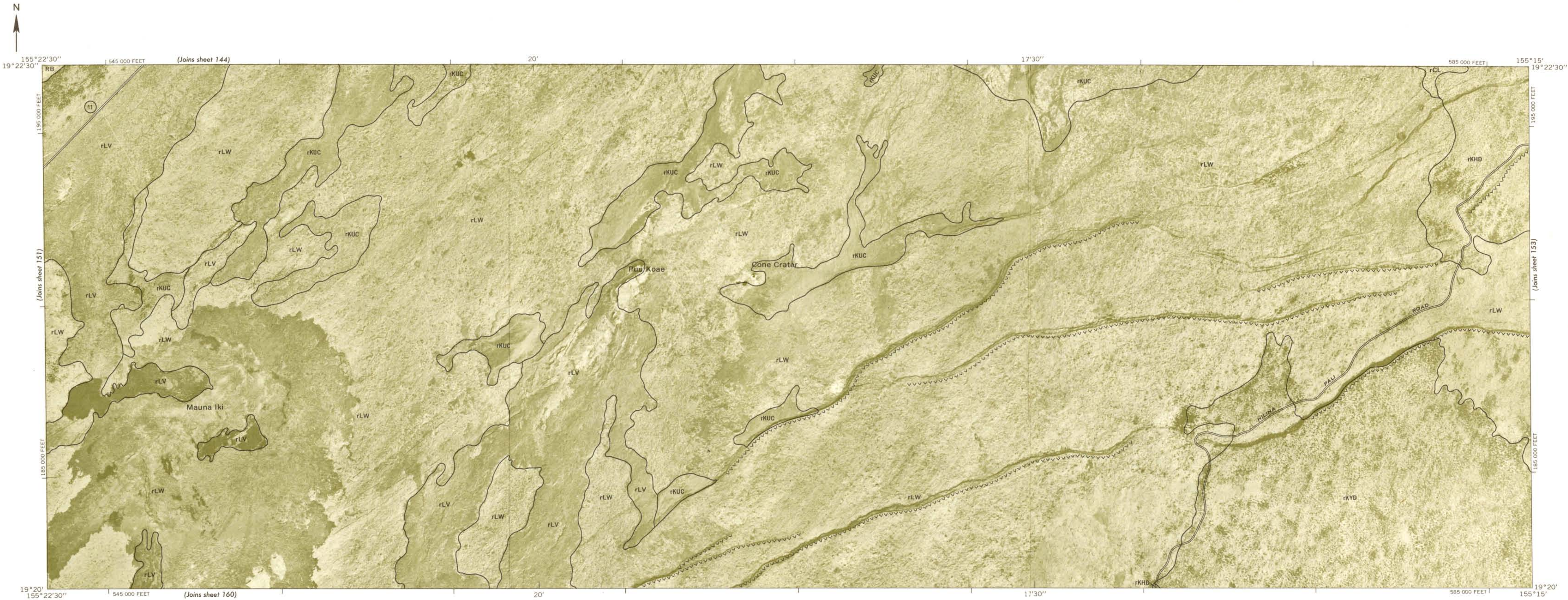


Photobase from 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 1. Old Hawaiian datum.

Scale 1:24 000

1 ¾ ½ ¼ 0 1 2 Miles

5000 4000 3000 2000 1000 0 5000 10000 Feet



Scale 1:24 000

1 ¾ ½ ¼ 0 1 2 Miles

5000 4000 3000 2000 1000 0 5000 10000 Feet

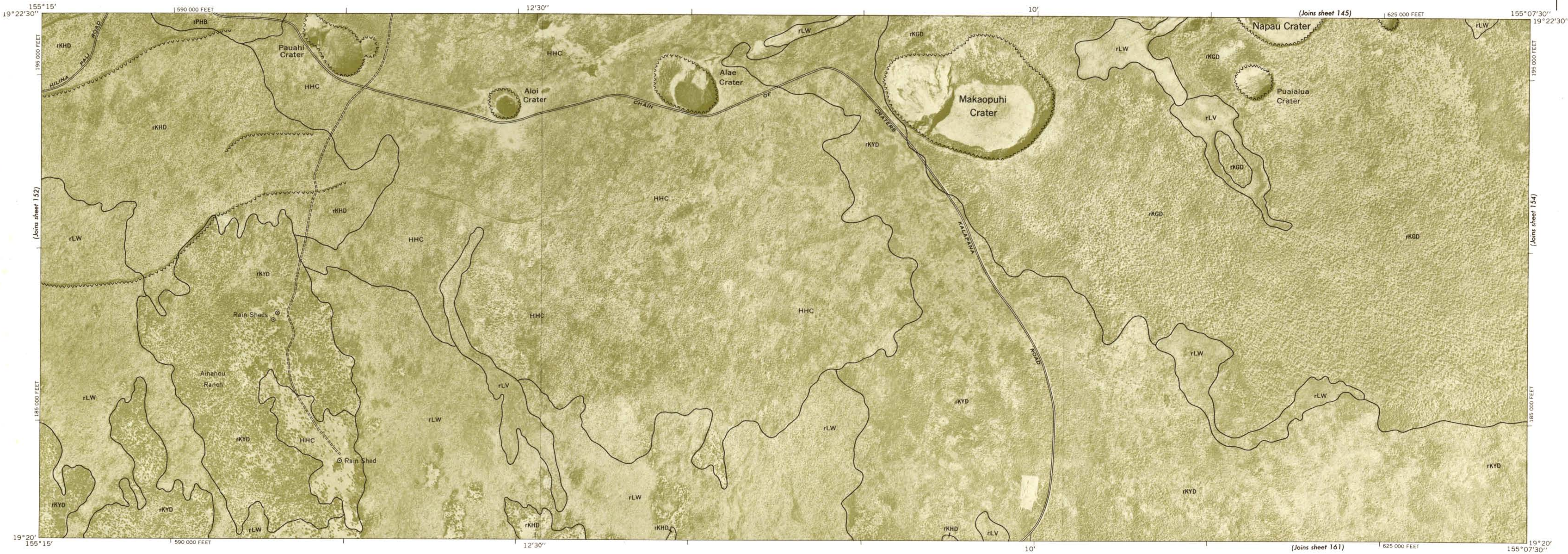
Photobase from 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 1. Old Hawaiian datum.

HAWAII ISLAND, HAWAII NO. 152

This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the University of Hawaii Agricultural Experiment Station.

153

N



This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the University of Hawaii Agricultural Experiment Station.

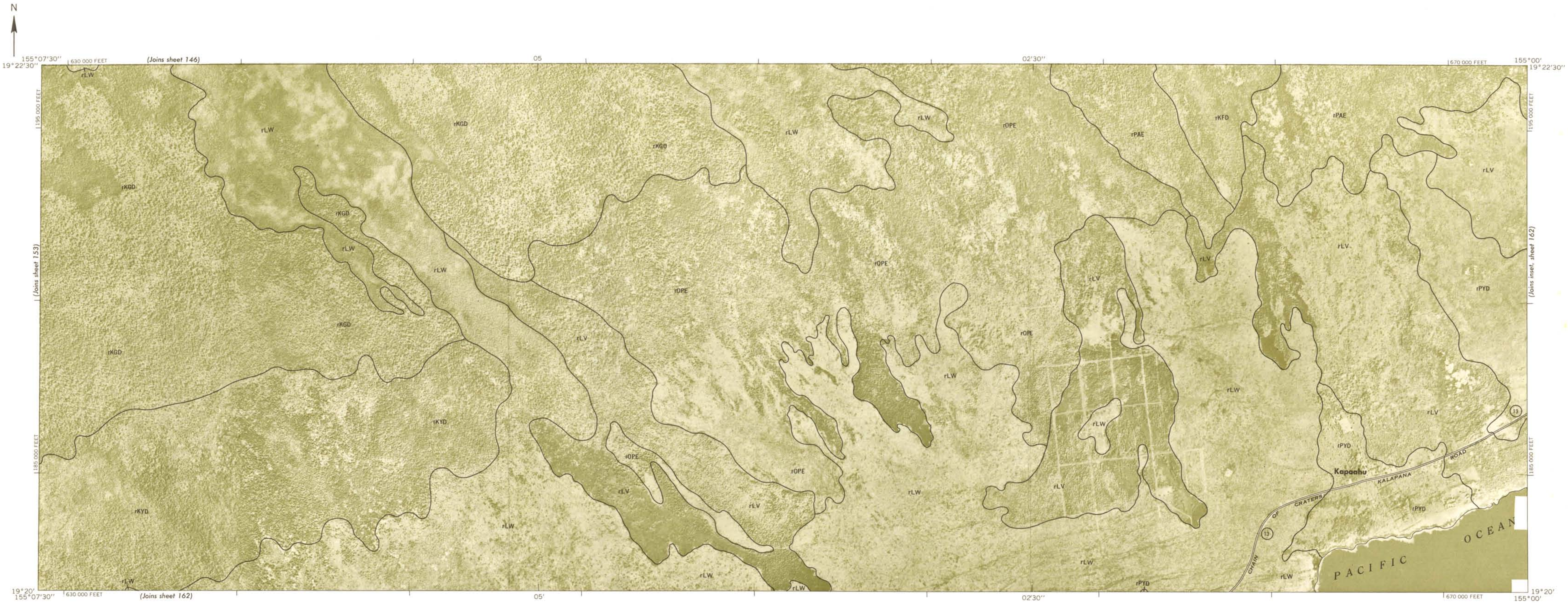
HAWAII ISLAND, HAWAII NO. 153

Photobase from 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 1. Old Hawaiian datum.

Scale 1:24 000

1 ¾ ½ ¼ 0 1 2 Miles

5000 4000 3000 2000 1000 0 5000 10000 Feet



Scale 1:24 000

1 ¾ ½ ¼ 0 1 2 Miles

5000 4000 3000 2000 1000 0 5000 10000 Feet

Photobase from 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 1. Old Hawaiian datum.

HAWAII ISLAND, HAWAII NO. 154

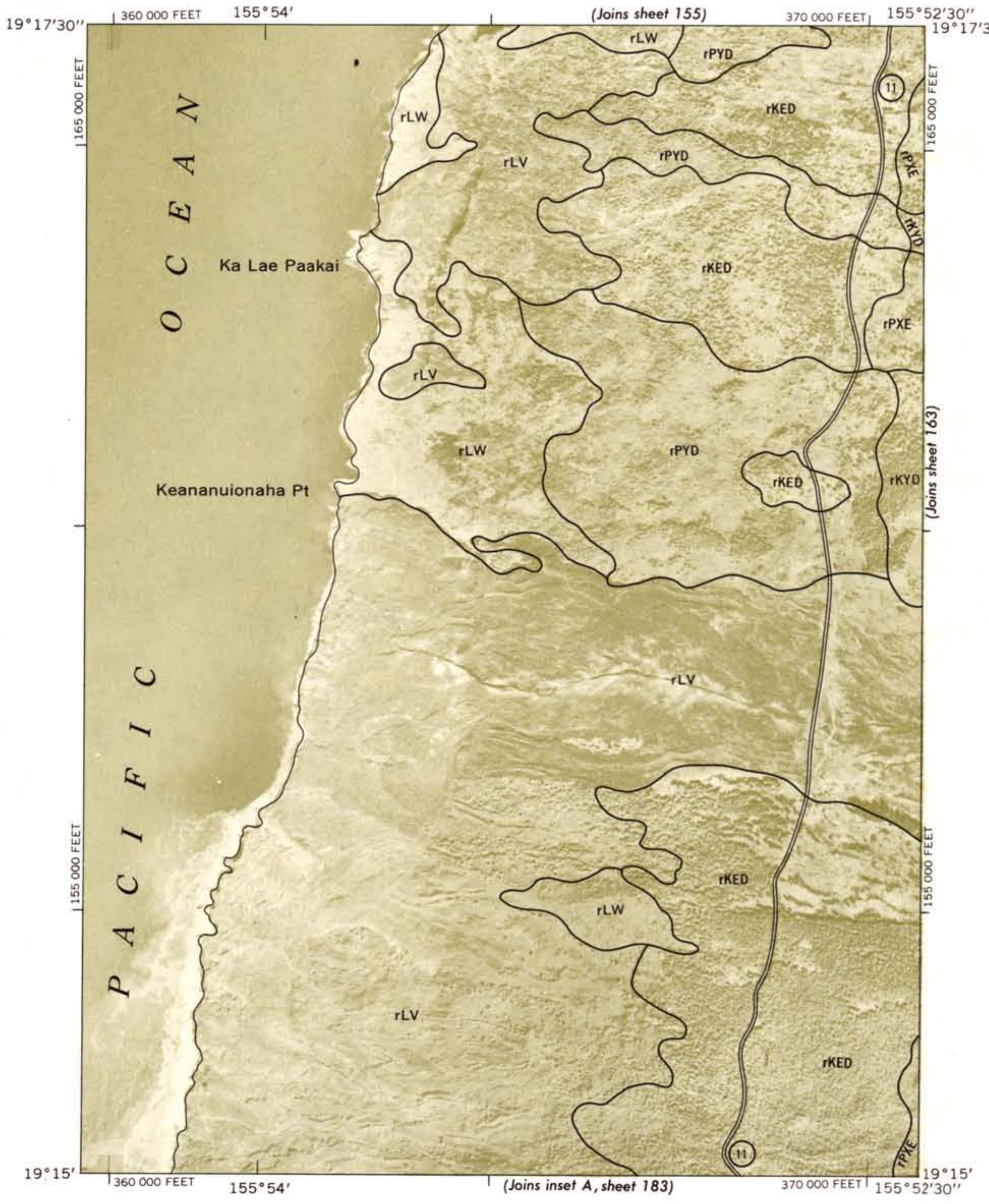
This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the University of Hawaii Agricultural Experiment Station.

N

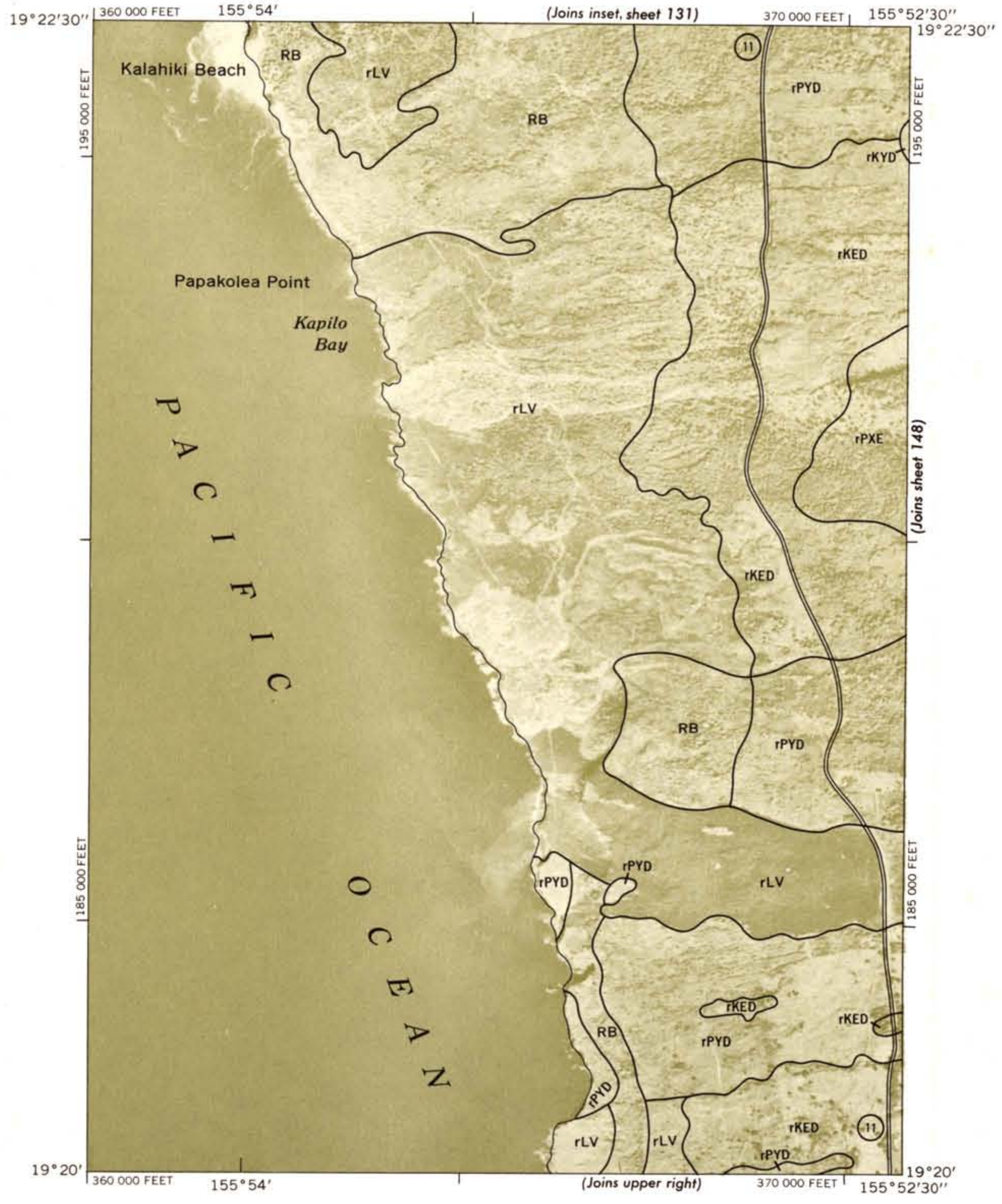
This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the University of Hawaii Agricultural Experiment Station.

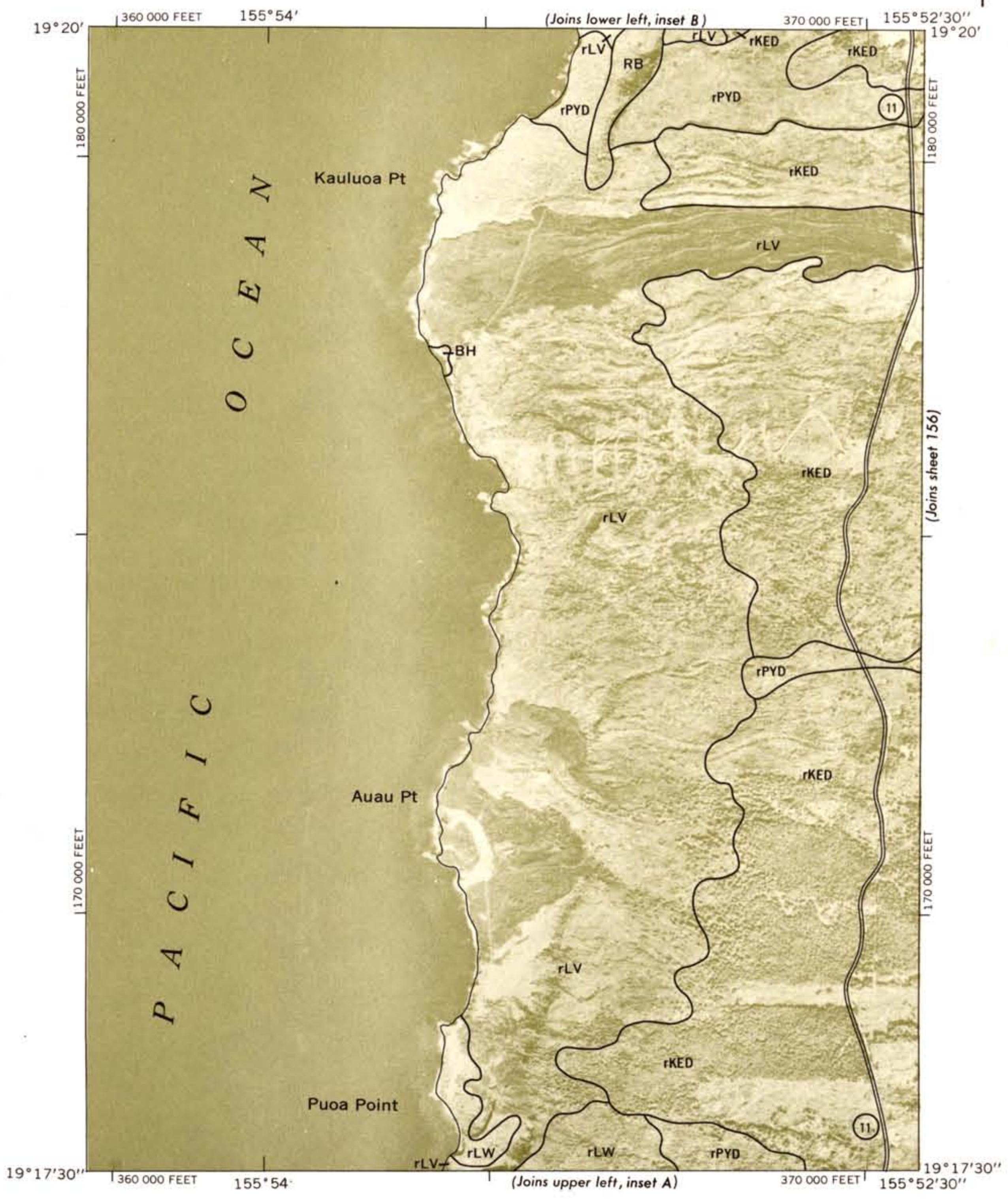
HAWAII ISLAND, HAWAII NO. 155

INSET A



INSET B





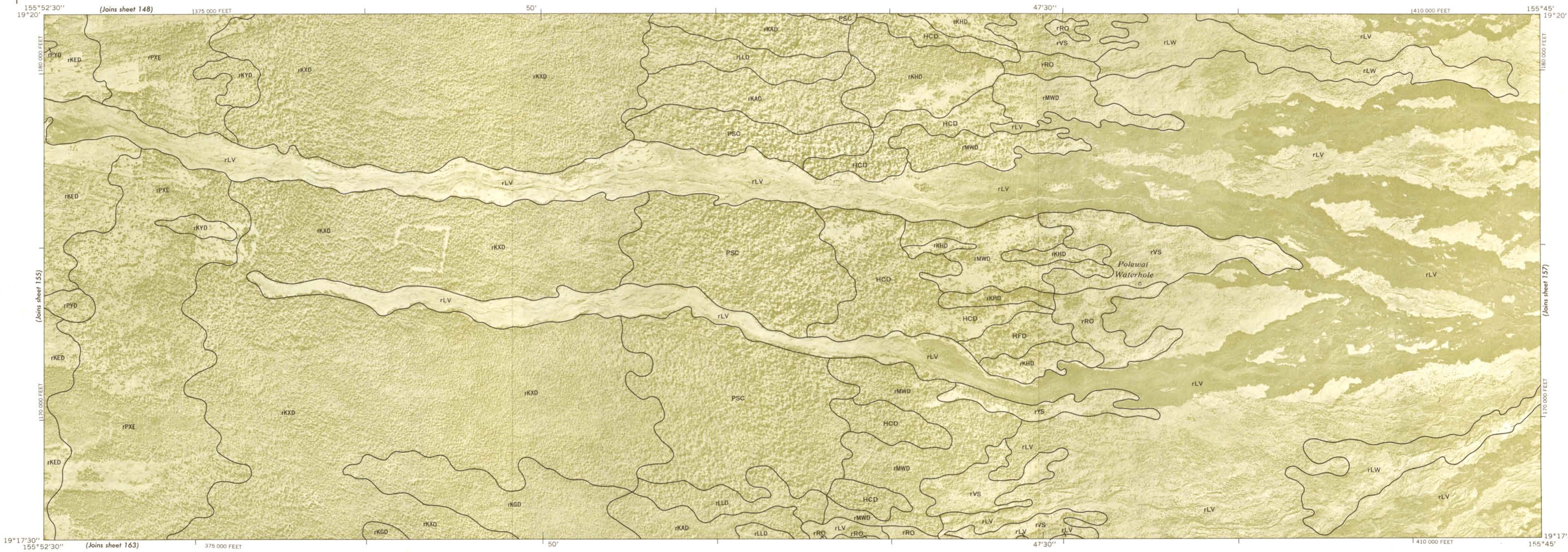
Photobase from 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 1. Old Hawaiian datum.

Scale 1:24 000

1 ¾ ½ ¼ 0 1 2 Miles

5000 4000 3000 2000 1000 0 5000 10000 Feet

N



Scale 1:24 000

1 ¾ ½ ¼ 0 1 2 Miles

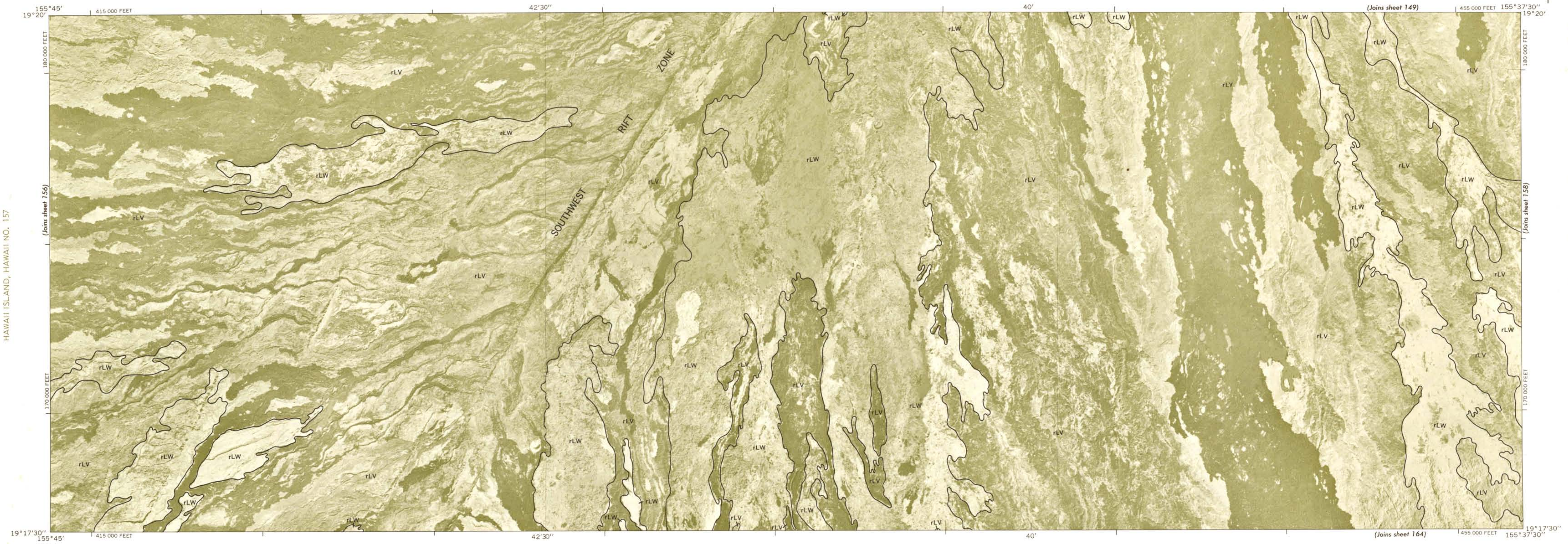
5000 4000 3000 2000 1000 0 5000 10000 Feet

Photobase from 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 1. Old Hawaiian datum.

This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the University of Hawaii Agricultural Experiment Station.

HAWAII ISLAND, HAWAII NO. 156

N



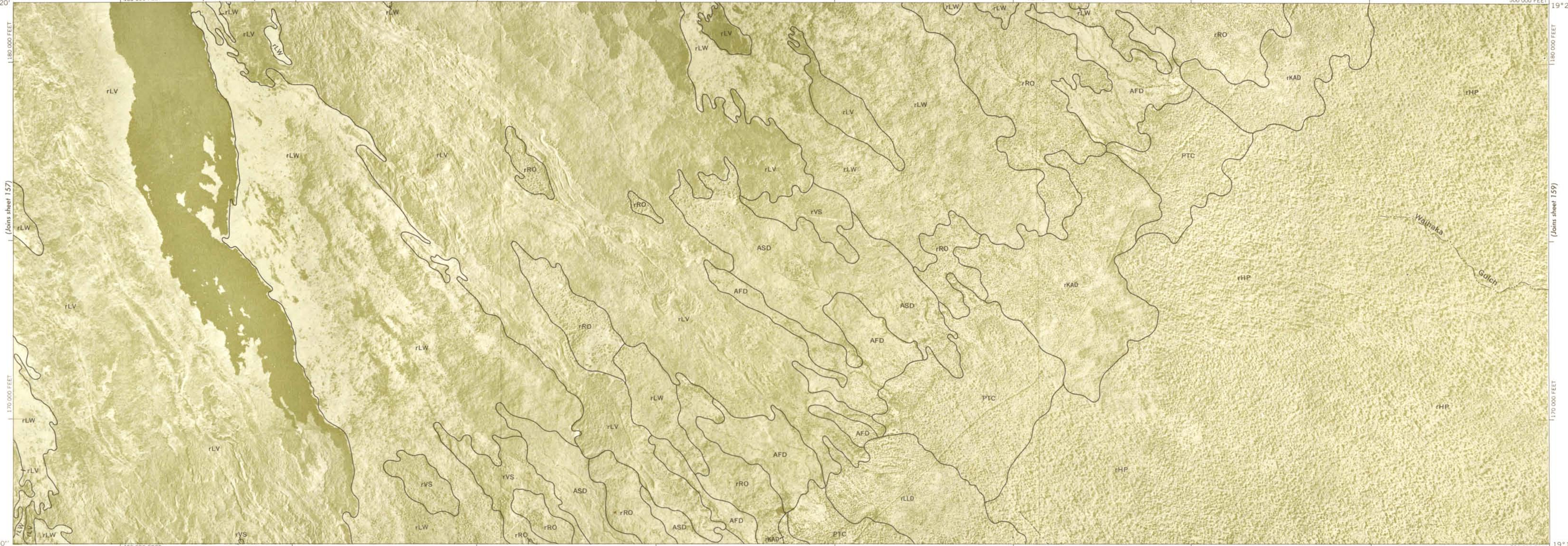
This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the University of Hawaii Agricultural Experiment Station.

HAWAII ISLAND, HAWAII NO. 157

Photobase from 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 1. Old Hawaiian datum.

Scale 1:24 000

N



Scale 1:24 000

1 ¾ ½ ¼ 0 1 2 Miles

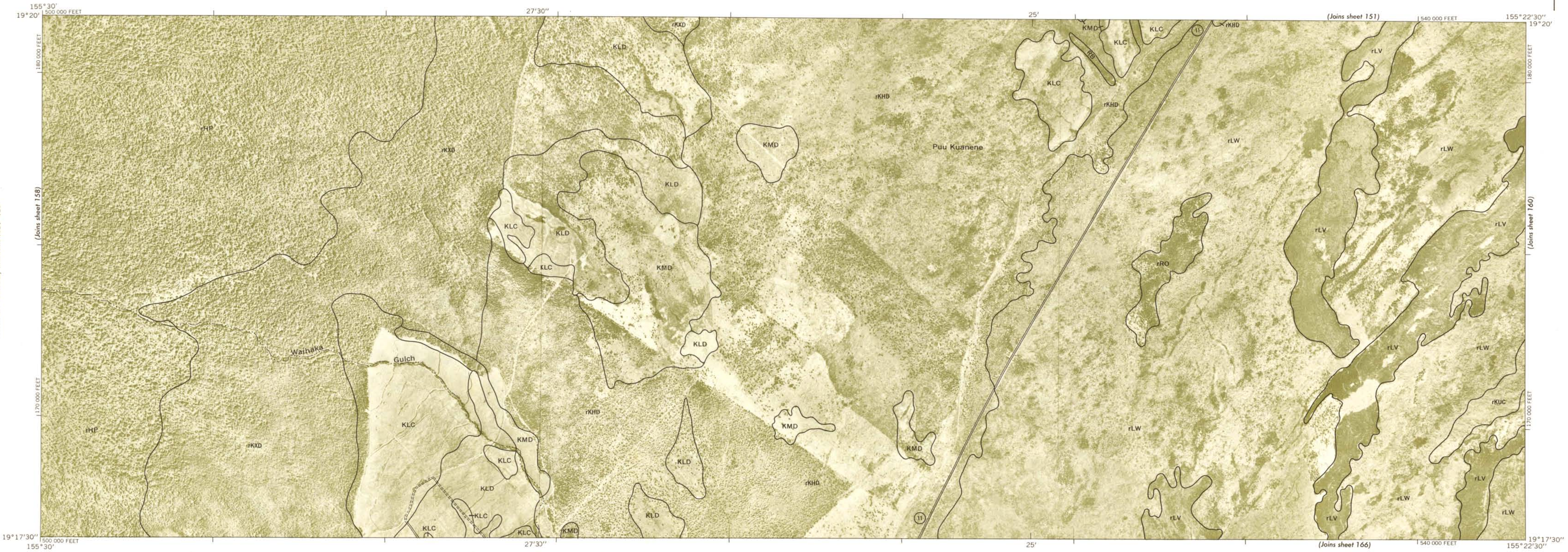
5000 4000 3000 2000 1000 0 5000 10000 Feet

Photobase from 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 1: Old Hawaiian datum.

HAWAII ISLAND, HAWAII NO. 158

This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the University of Hawaii Agricultural Experiment Station.

N



This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the University of Hawaii Agricultural Experiment Station.

HAWAII ISLAND, HAWAII NO. 159

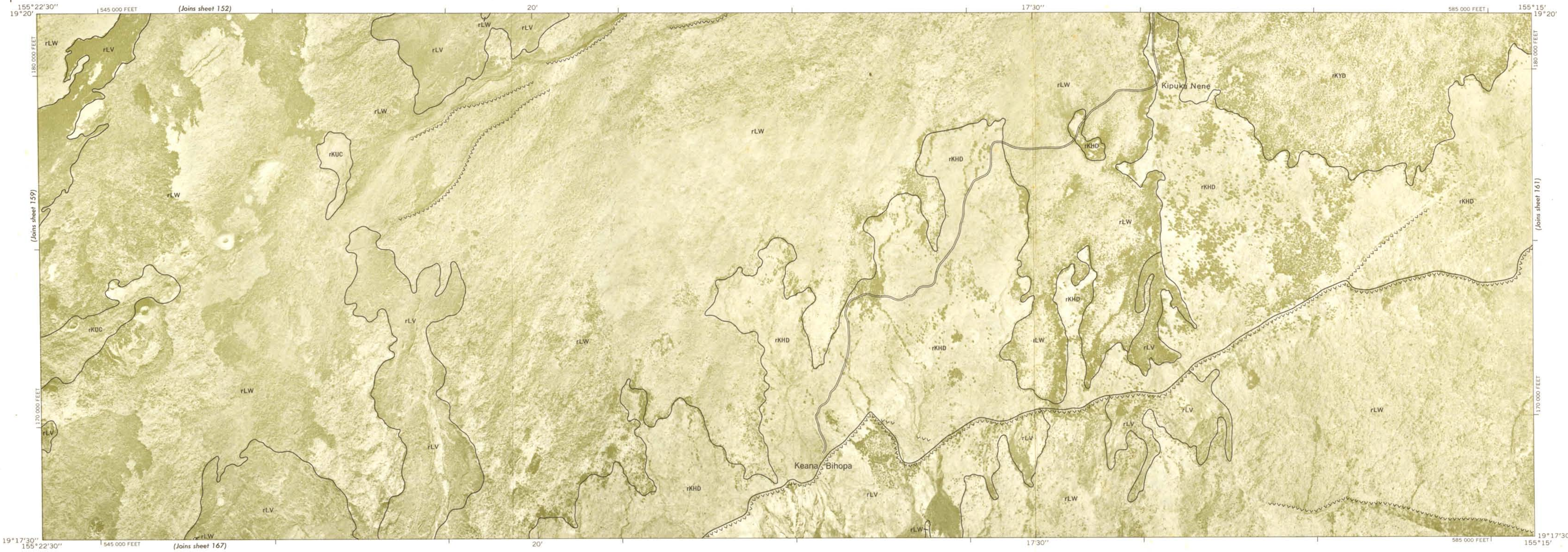
Photobase from 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 1, Old Hawaiian datum.

Scale 1:24 000

1 ¾ ½ ¼ 0 1 2 Miles

5000 4000 3000 2000 1000 0 5000 10000 Feet

N



Scale 1:24 000

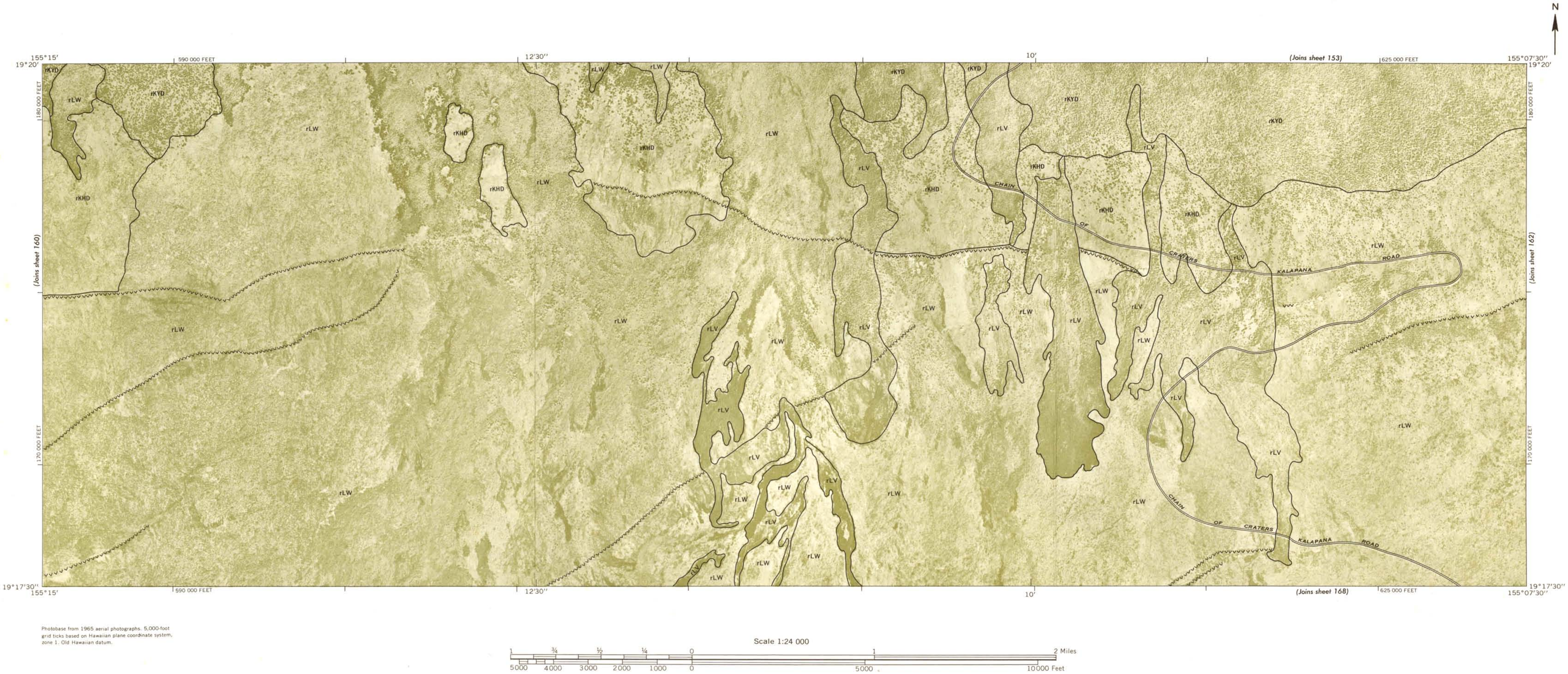
1 ¾ ½ ¼ 0 1 2 Miles

5000 4000 3000 2000 1000 0 5000 10000 Feet

Photobase from 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 1. Old Hawaiian datum.

HAWAII ISLAND, HAWAII NO. 160

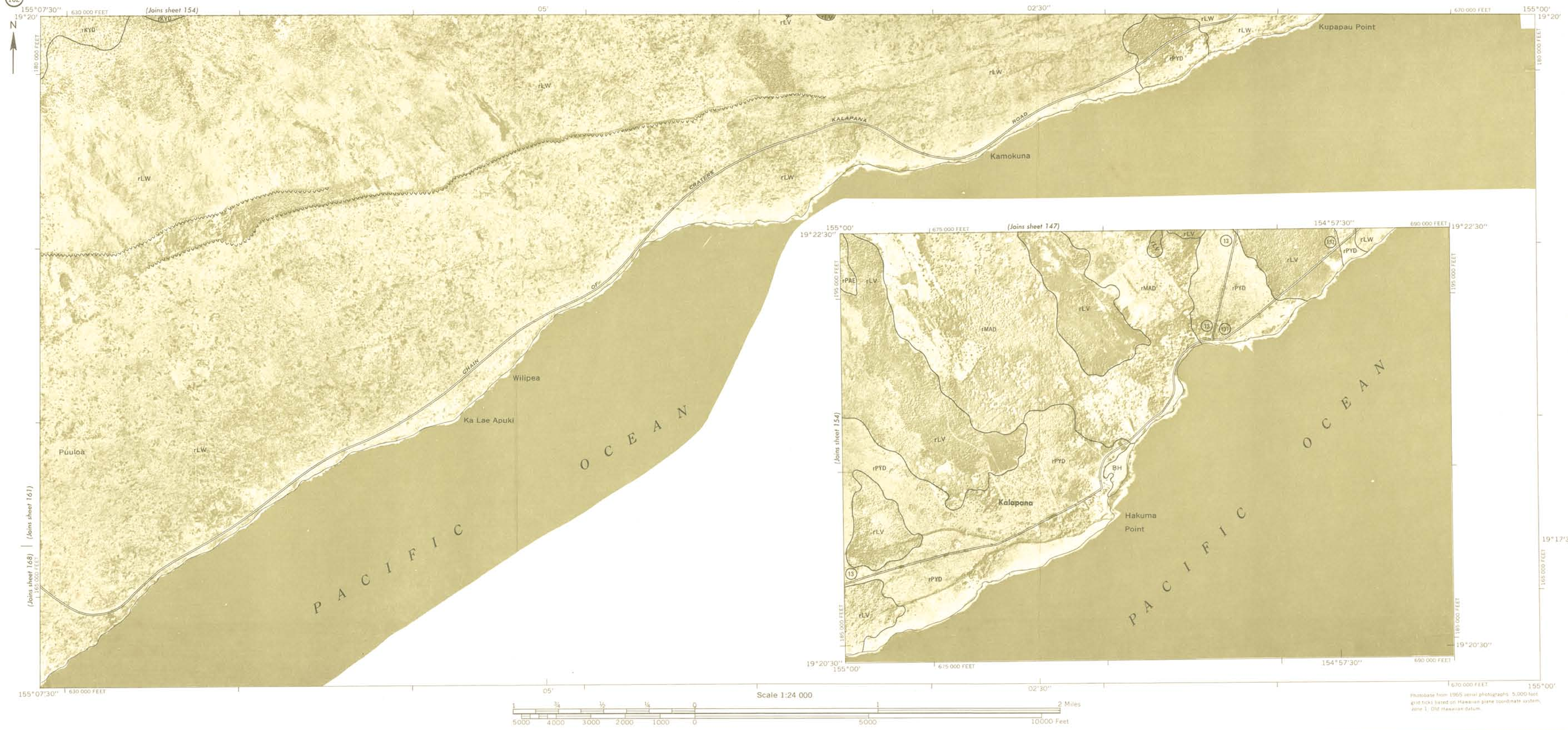
This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the University of Hawaii Agricultural Experiment Station.



HAWAII ISLAND, HAWAII NO. 161

This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the University of Hawaii Agricultural Experiment Station.

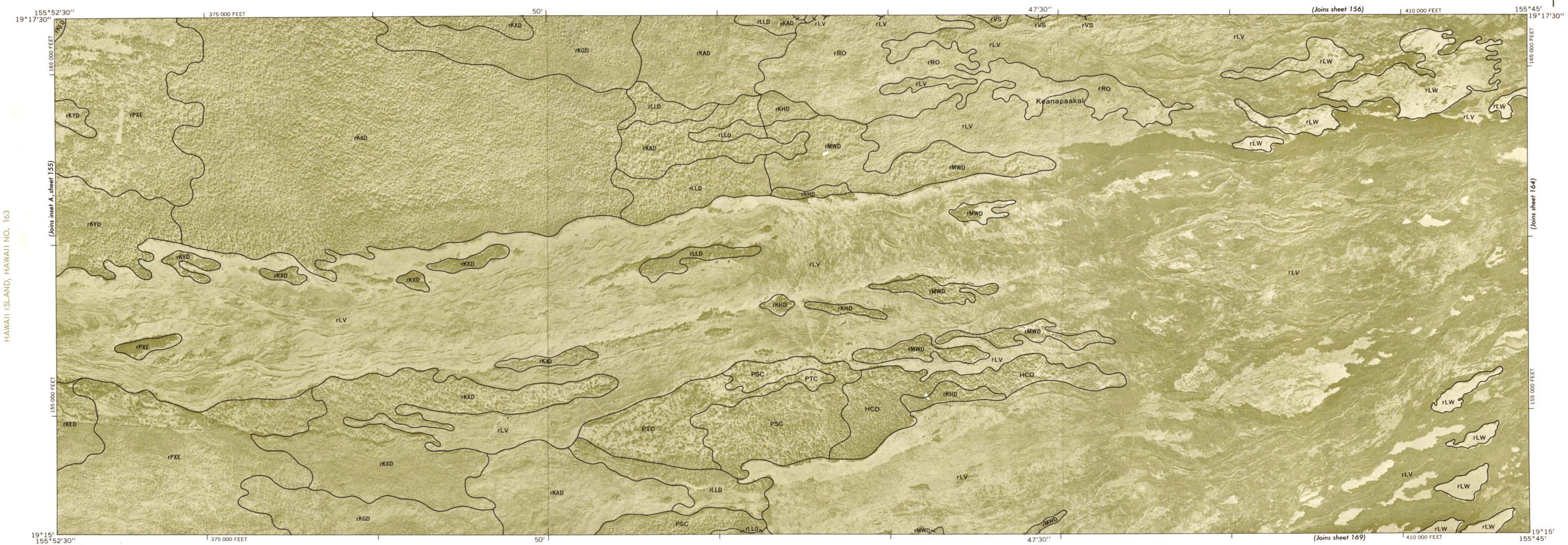
Photobase from 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 1. Old Hawaiian datum.



Photobase from 1965 aerial photographs. 5,000 foot grid ticks based on Hawaiian plane coordinate system, zone 1. Old Hawaiian datum.

This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the University of Hawaii Agricultural Experiment Station.

N



This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the University of Hawaii Agricultural Experiment Station.

HAWAII ISLAND, HAWAII NO. 163

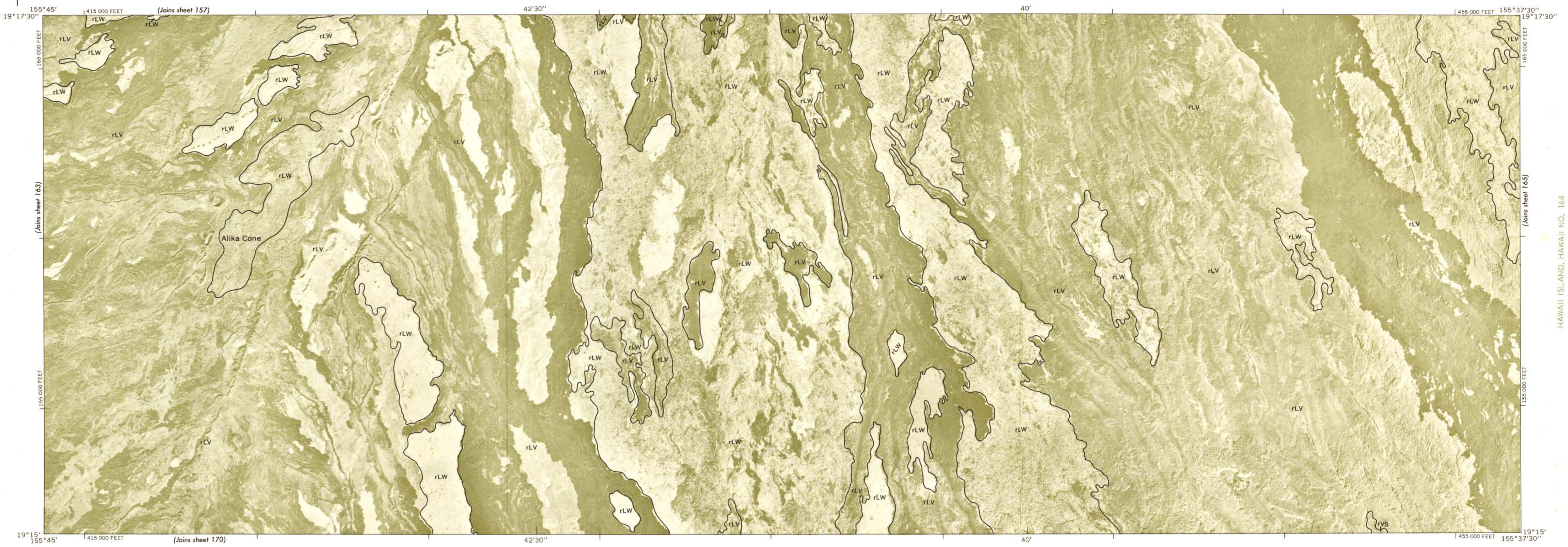
Photobase from 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 1. Old Hawaiian datum.

Scale 1:24 000

1 ¾ ½ ¼ 0 1 2 Miles

5000 4000 3000 2000 1000 0 5000 10000 Feet

N



Scale 1:24 000

1 ¾ ½ ¼ 0 1 2 Miles

5000 4000 3000 2000 1000 0 5000 10000 Feet

Photobase from 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 1. Old Hawaiian datum.

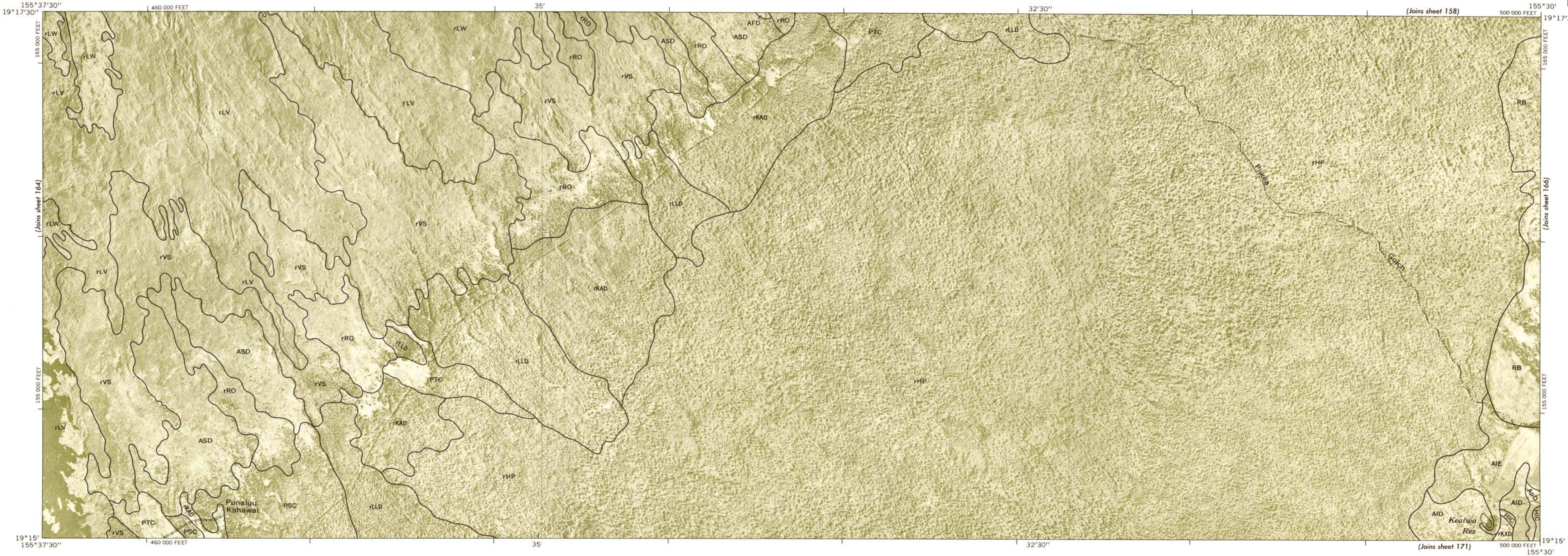
This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the University of Hawaii Agricultural Experiment Station.

HAWAII ISLAND, HAWAII NO. 164

N

This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the University of Hawaii Agricultural Experiment Station.

HAWAII ISLAND, HAWAII NO. 165

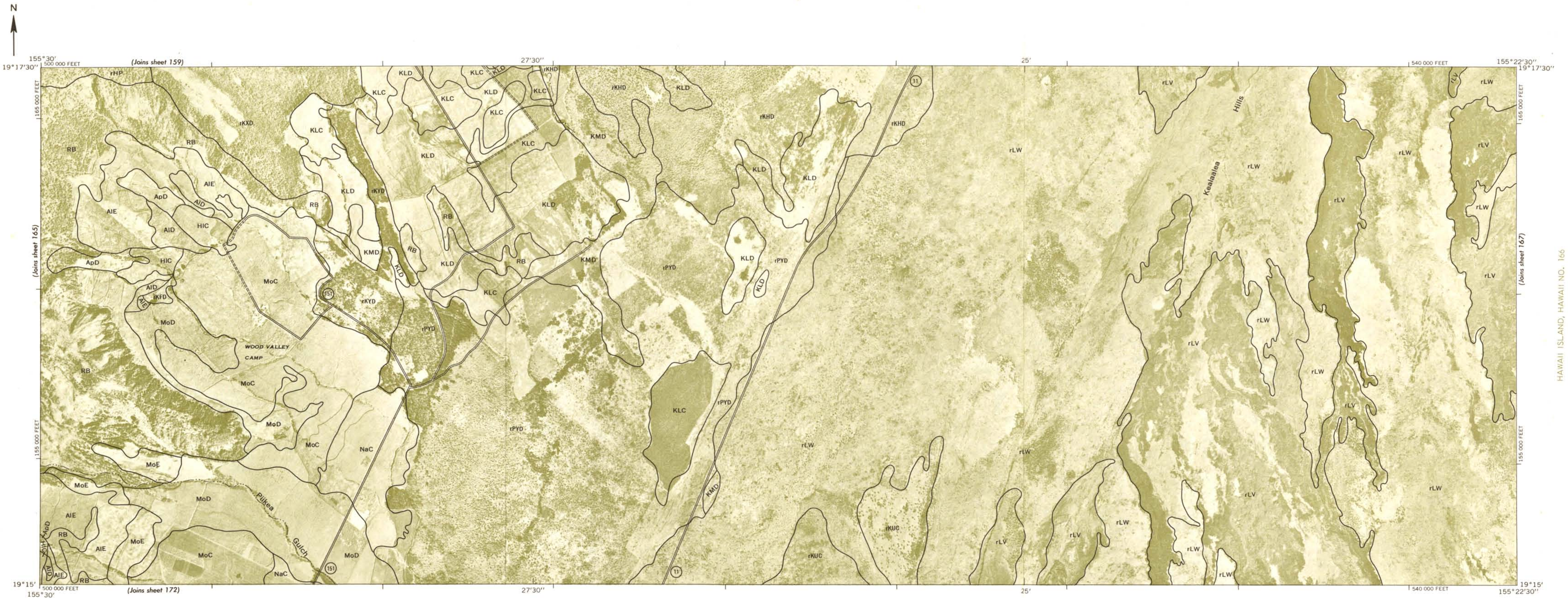


Photobase from 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 1. Old Hawaiian datum.

Scale 1:24 000

1 ¾ ½ ¼ 0 1 2 Miles

5000 4000 3000 2000 1000 0 5000 10000 Feet



Scale 1:24 000

1 ¾ ½ ¼ 0 1 2 Miles

5000 4000 3000 2000 1000 0 5000 10000 Feet

Photobase from 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 1. Old Hawaiian datum.

HAWAII ISLAND, HAWAII NO. 166

This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the University of Hawaii Agricultural Experiment Station.

This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the University of Hawaii Agricultural Experiment Station.

HAWAII ISLAND, HAWAII NO. 167

Photobase from 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 1. Old Hawaiian datum.

Scale 1:24 000

1 ¾ ½ ¼ 0 1 2 Miles

5000 4000 3000 2000 1000 0 5000 10000 Feet

(168)

Scale 1:24 000

1 ¾ ½ ¼ 0 1 2 Miles

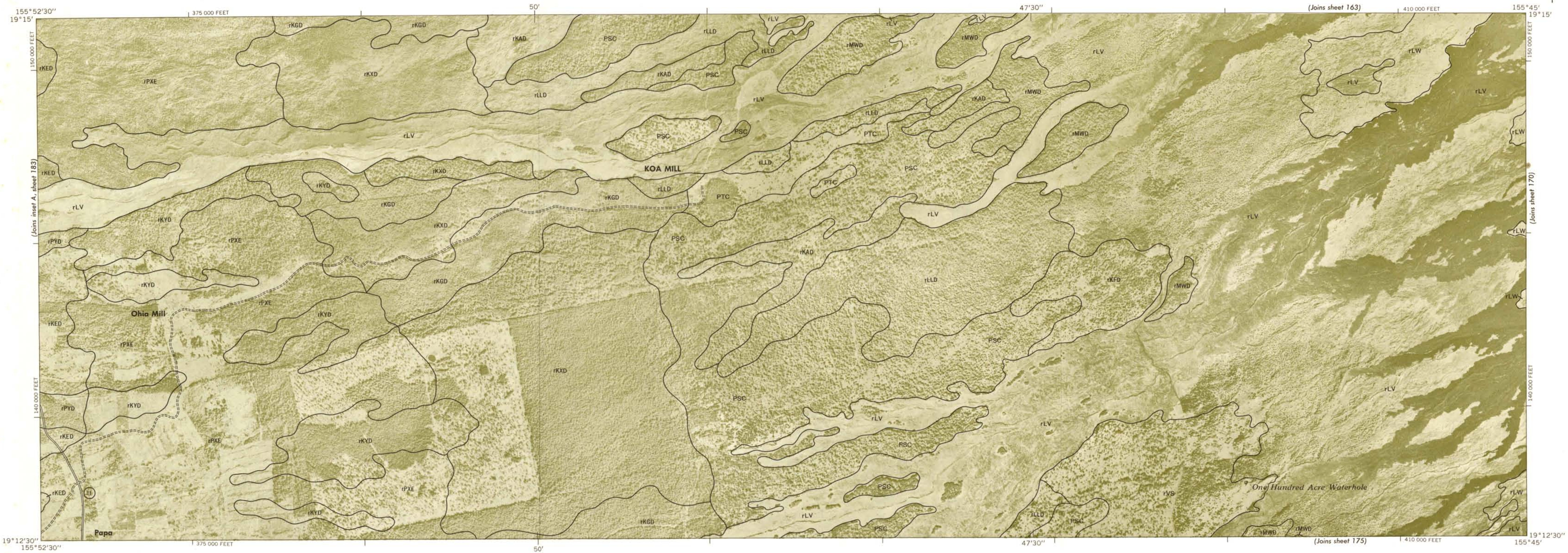
5000 4000 3000 2000 1000 0 5000 10000 Feet

Photobase from 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 1, Old Hawaiian datum.

HAWAII ISLAND, HAWAII NO. 168

This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the University of Hawaii Agricultural Experiment Station.

N



This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the University of Hawaii Agricultural Experiment Station.

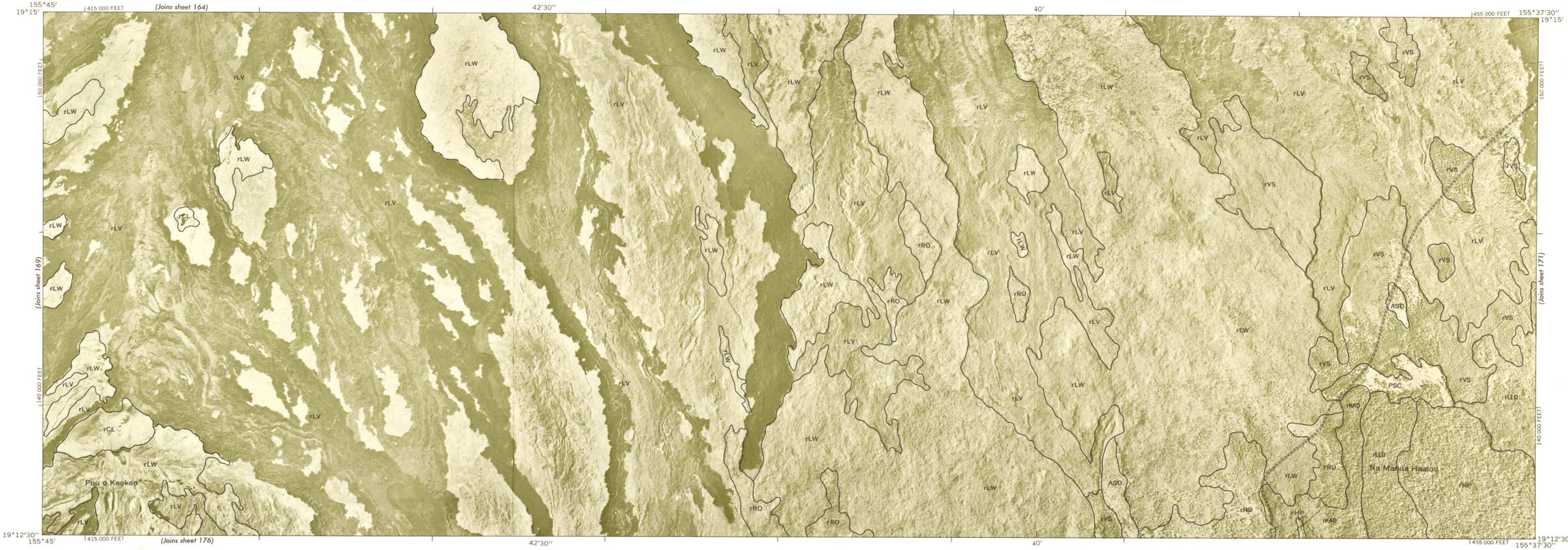
HAWAII ISLAND, HAWAII NO. 169

Photobase from 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 1. Old Hawaiian datum.

Scale 1:24 000

1 ¾ ½ ¼ 0 1 2 Miles

5000 4000 3000 2000 1000 0 5000 10000 Feet



Scale 1:24 000

1 ¾ ½ ¼ 0 1 2 Miles

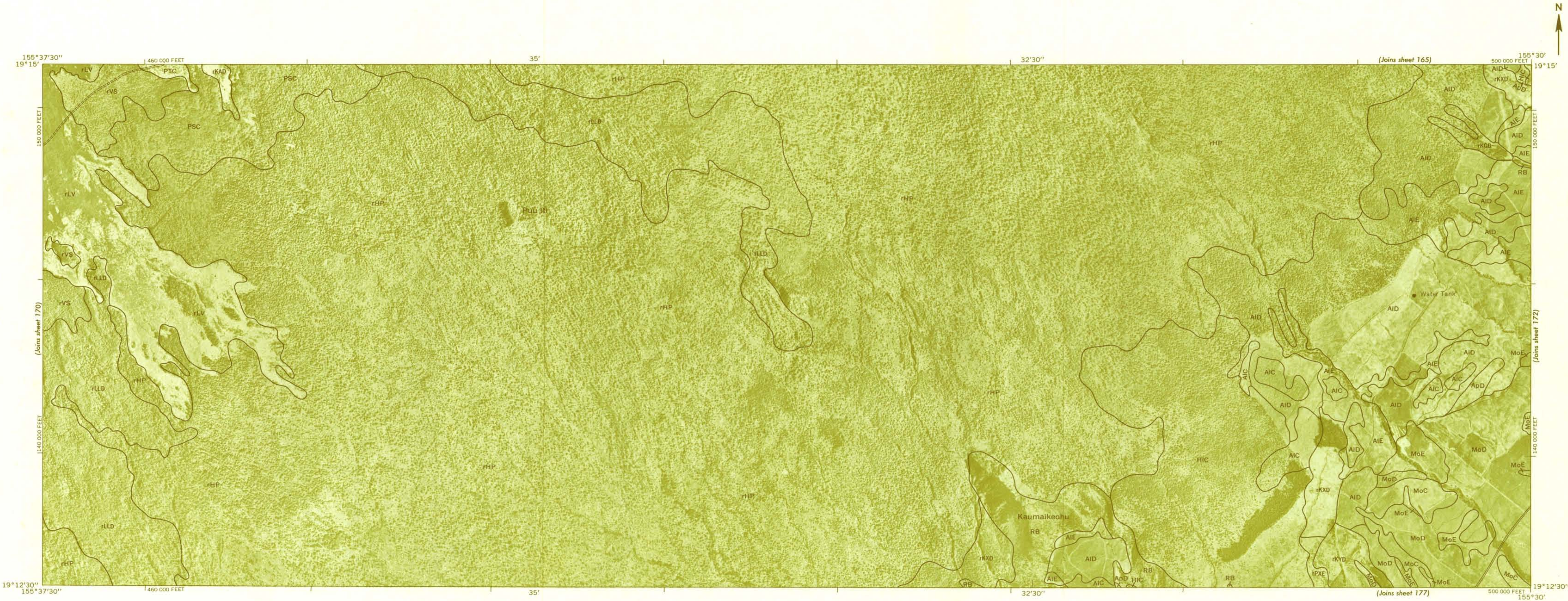
5000 4000 3000 2000 1000 0 5000 10000 Feet

Photobase from 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 1. Old Hawaiian datum.

This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the University of Hawaii Agricultural Experiment Station.

This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the University of Hawaii Agricultural Experiment Station.

HAWAII ISLAND, HAWAII NO. 171



Photobase from 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 1. Old Hawaiian datum.

Scale 1:24 000

1 ¾ ½ ¼ 0 1 2 Miles

5000 4000 3000 2000 1000 0 5000 10000 Feet

Scale 1:24 000

1 ¾ ½ ¼ 0 1 2 Miles

5000 4000 3000 2000 1000 0 5000 10000 Feet

Photobase from 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 1. Old Hawaiian datum.

HAWAII ISLAND, HAWAII NO. 172

This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the University of Hawaii Agricultural Experiment Station.

Photobase from 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 1. Old Hawaiian datum.

Scale 1:24 000

1 ¾ ½ ¼ 0 1 2 Miles

5000 4000 3000 2000 1000 0 5000 10000 Feet

This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the University of Hawaii Agricultural Experiment Station.

HAWAII ISLAND, HAWAII NO. 173

HAWAII ISLAND, HAWAII — SHEET NUMBER 174

N

Scale 1:24 000

1 ¾ ½ ¼ 0 1 2 Miles

5000 4000 3000 2000 1000 0 5000 10000 Feet

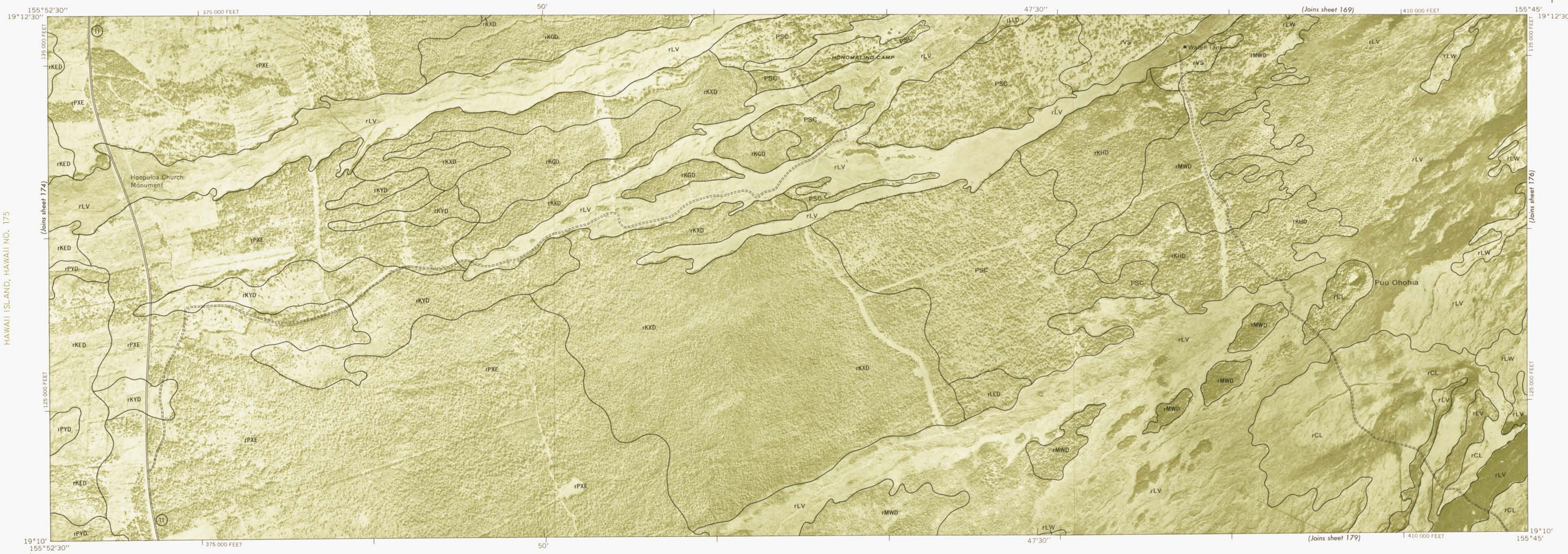
Photobase from 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 1. Old Hawaiian datum.

HAWAII ISLAND, HAWAII NO. 174

This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the University of Hawaii Agricultural Experiment Station.

This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the University of Hawaii Agricultural Experiment Station.

HAWAII ISLAND, HAWAII NO. 175



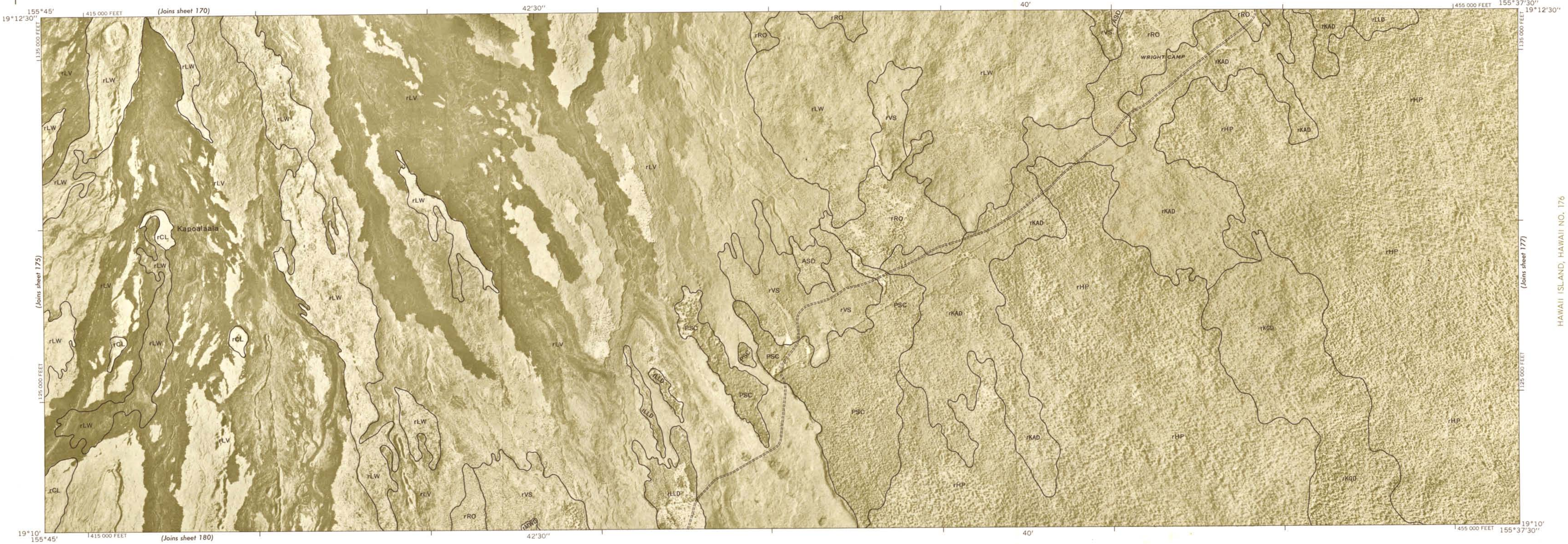
Photobase from 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 1. Old Hawaiian datum.

Scale 1:24 000

1 ¾ ½ ¼ 0 1 2 Miles

5000 4000 3000 2000 1000 0 5000 10000 Feet

N



Scale 1:24 000

1 ¾ ½ ¼ 0 1 2 Miles

5000 4000 3000 2000 1000 0 5000 10000 Feet

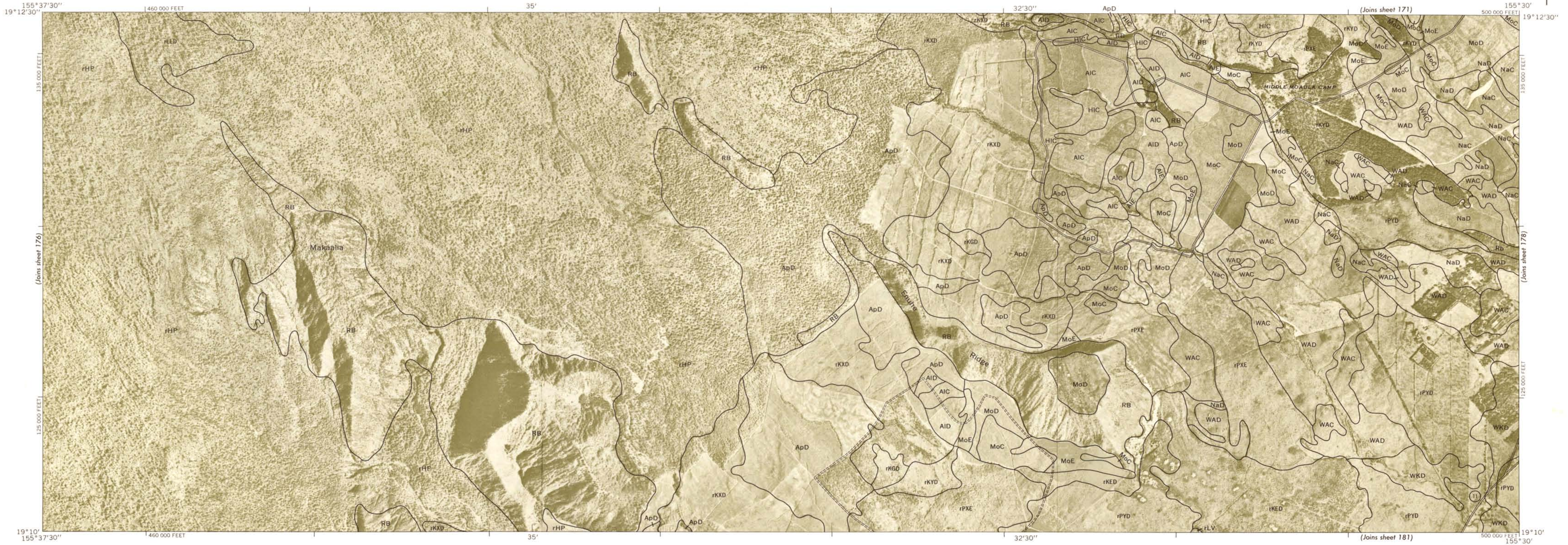
Photobase from 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 1. Old Hawaiian datum.

HAWAII ISLAND, HAWAII NO. 176

This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the University of Hawaii Agricultural Experiment Station.

177

N



This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the University of Hawaii Agricultural Experiment Station.

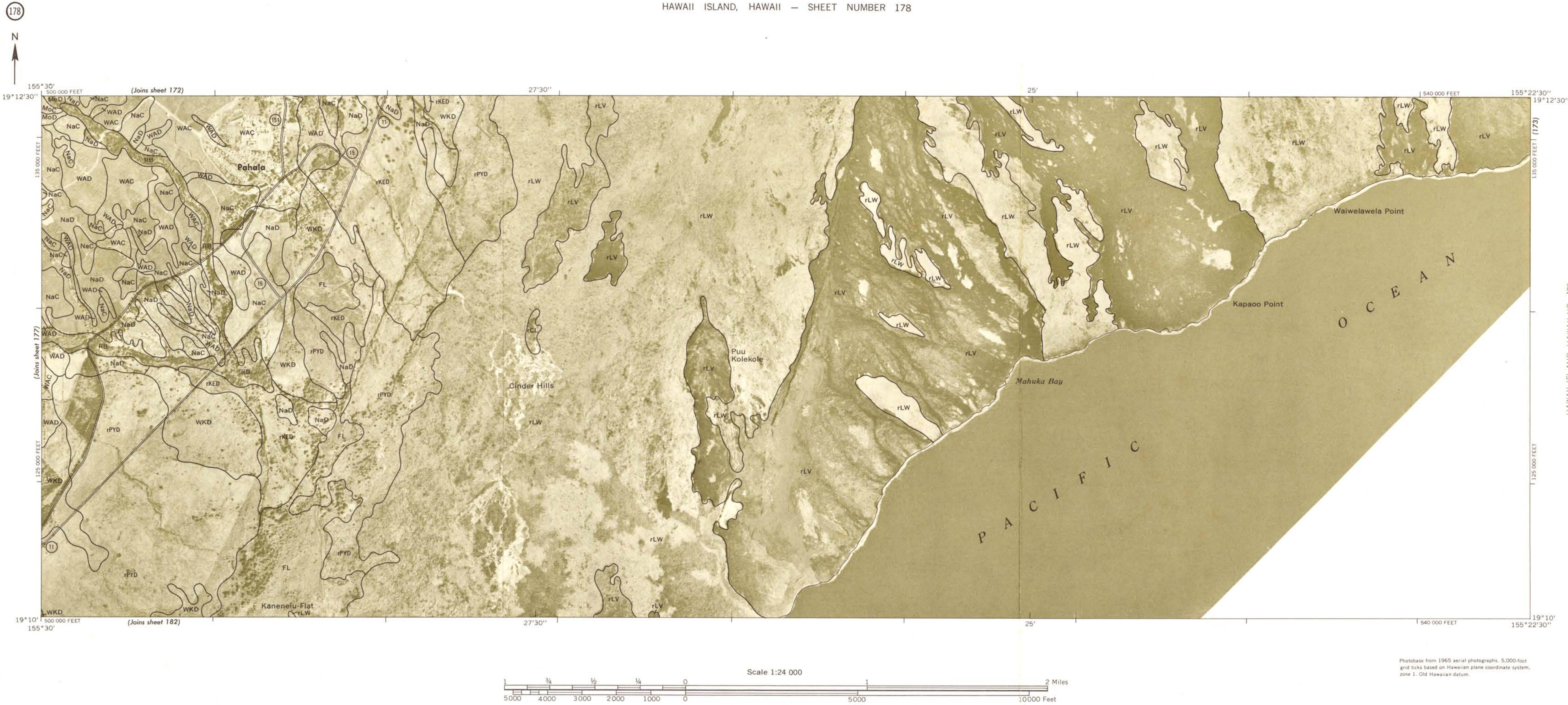
HAWAII ISLAND, HAWAII, NO. 177

Photobase from 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 1. Old Hawaiian datum.

Scale 1:24 000

1 ¾ ½ ¼ 0 1 2 Miles

5000 4000 3000 2000 1000 0 5000 10000 Feet

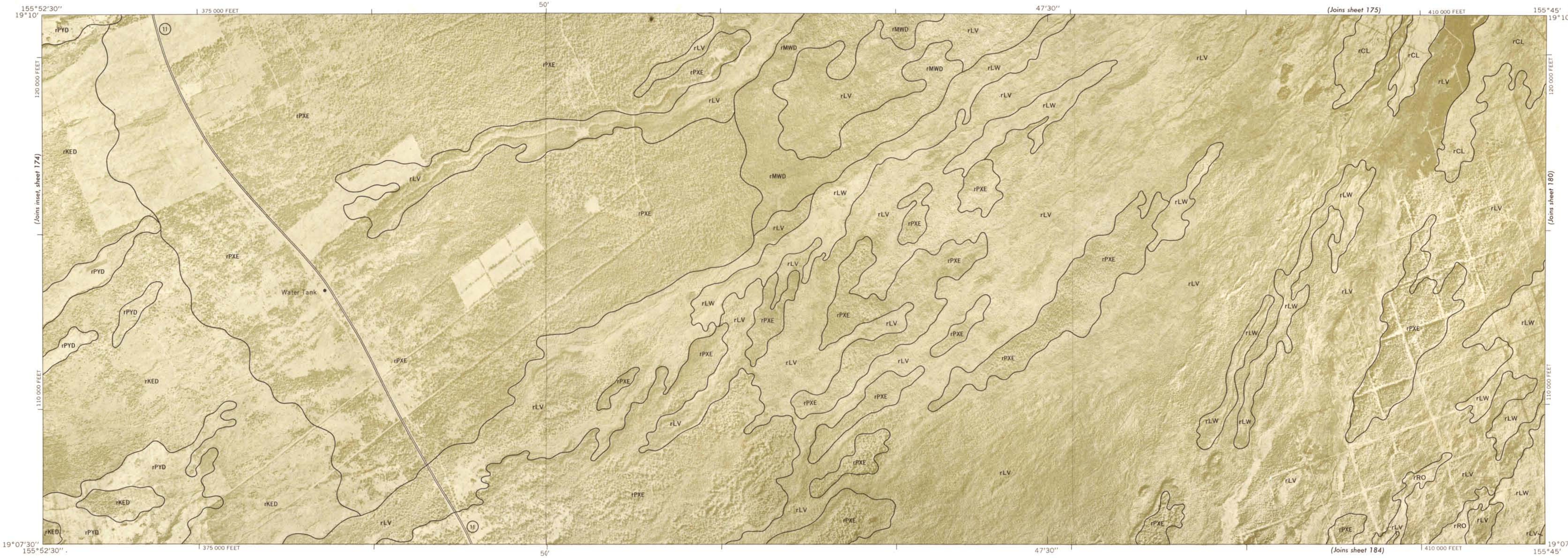


Photobase from 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 1. Old Hawaiian datum.

HAWAII ISLAND, HAWAII NO. 178

This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the University of Hawaii Agricultural Experiment Station.

N



This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the University of Hawaii Agricultural Experiment Station.

HAWAII ISLAND, HAWAII NO. 179

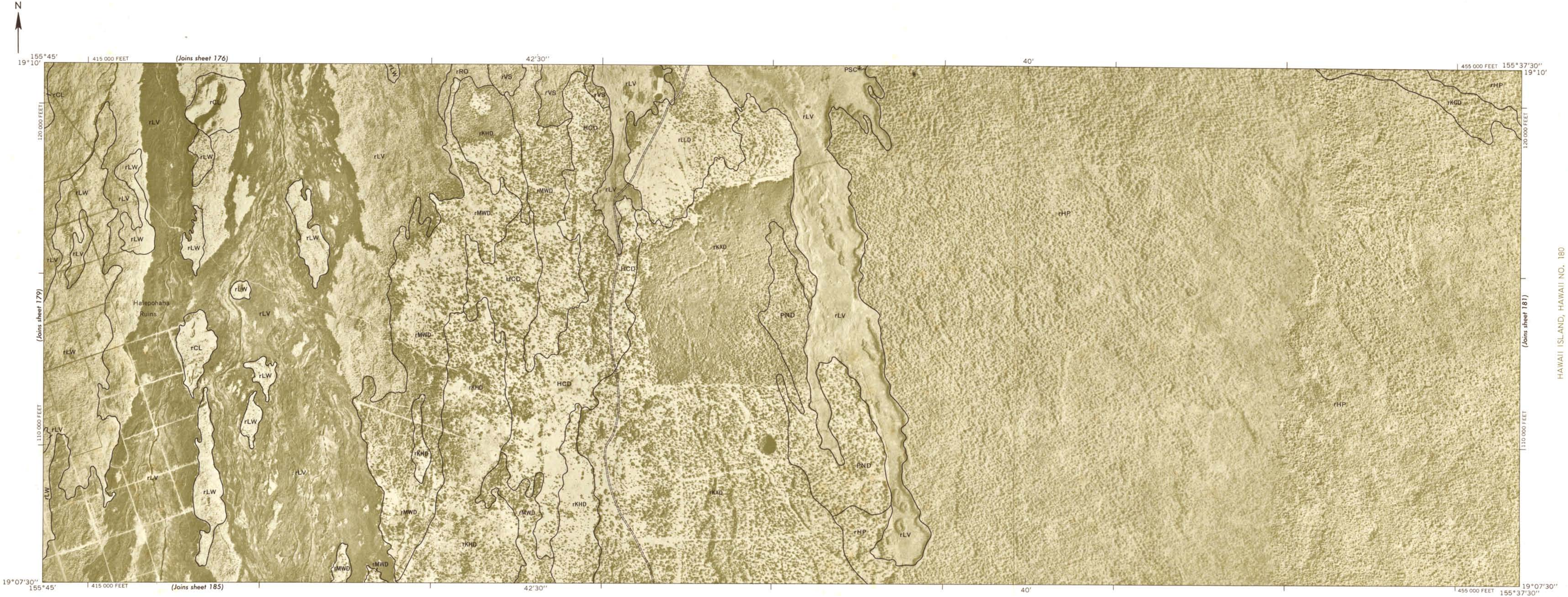
Photobase from 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 1. Old Hawaiian datum.

Scale 1:24 000

1 ¾ ½ ¼ 0 1 2 Miles

5000 4000 3000 2000 1000 0 5000 10000 Feet

HAWAII ISLAND, HAWAII — SHEET NUMBER 180



Scale 1:24 000

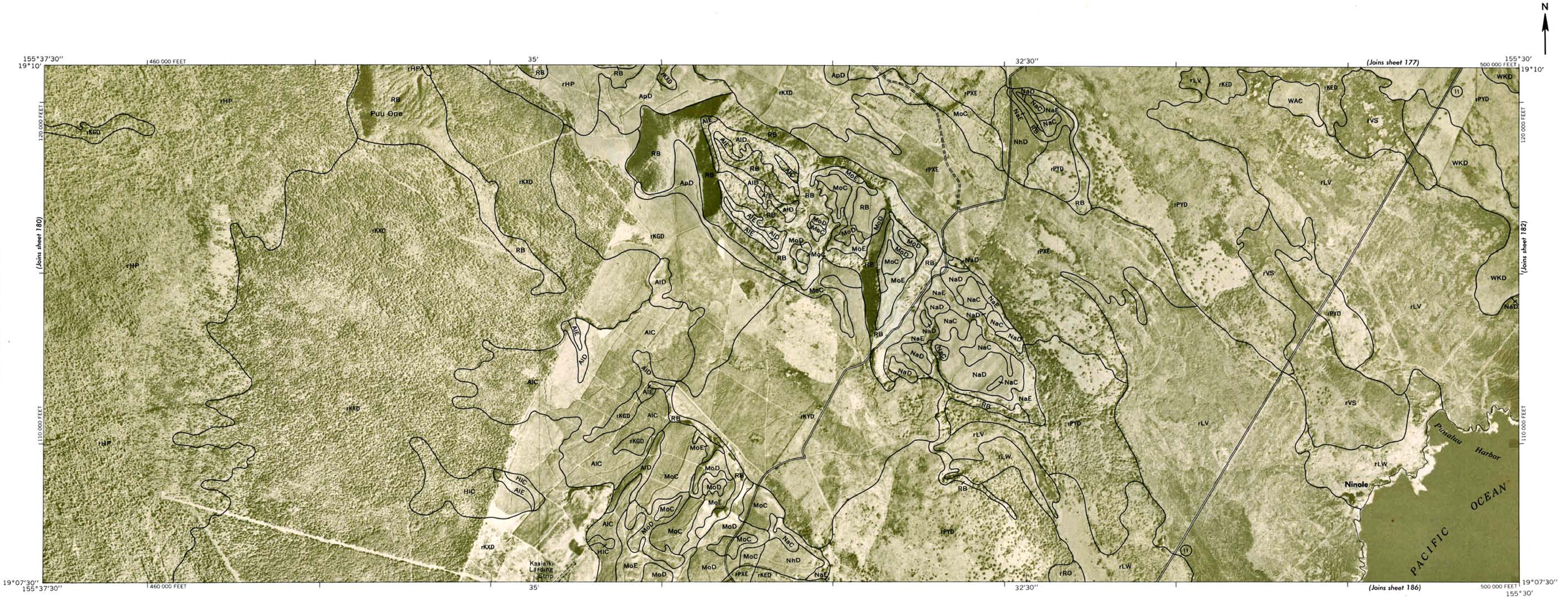
1 ¾ ½ ¼ 0 1 2 Miles

5000 4000 3000 2000 1000 0 5000 10000 Feet

Photobase from 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 1. Old Hawaiian datum.

HAWAII ISLAND, HAWAII NO. 180

This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the University of Hawaii Agricultural Experiment Station.



This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the University of Hawaii Agricultural Experiment Station.

HAWAII ISLAND, HAWAII NO. 181

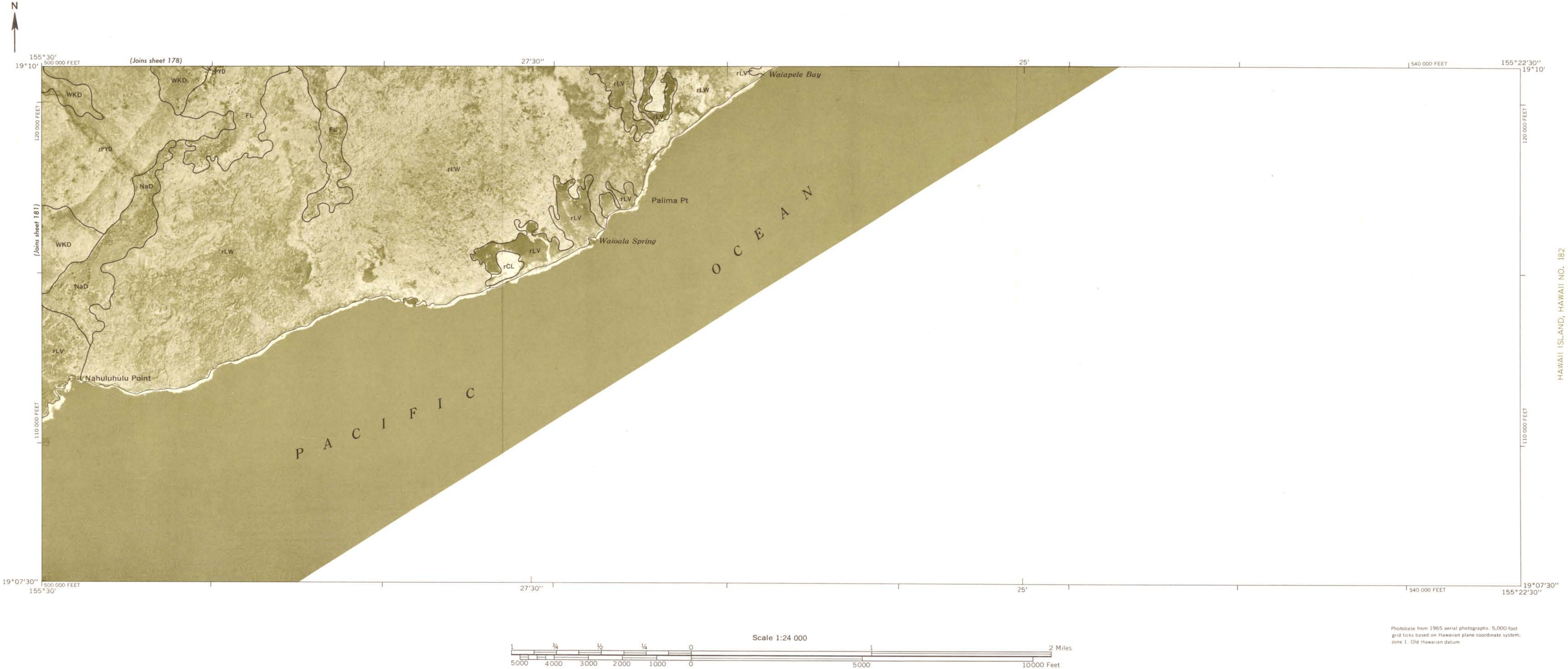
Photobase from 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 1. Old Hawaiian datum.

Scale 1:24 000

1 ¾ ½ ¼ 0 1 2 Miles

5000 4000 3000 2000 1000 0 5000 10000 Feet

HAWAII ISLAND, HAWAII — SHEET NUMBER 182



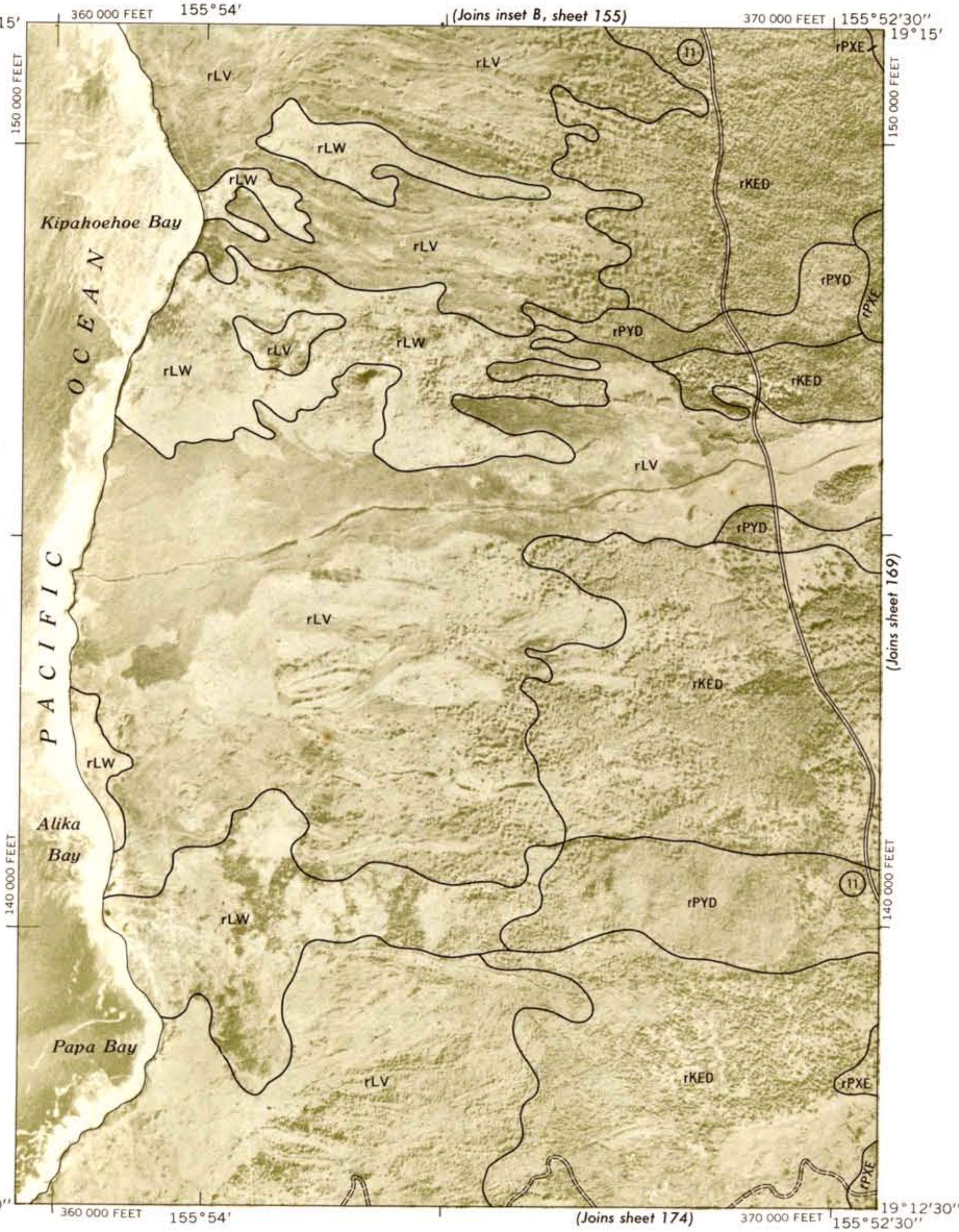
Photobase from 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 1. Old Hawaiian datum.

HAWAII ISLAND, HAWAII NO. 182

This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the University of Hawaii Agricultural Experiment Station.

N

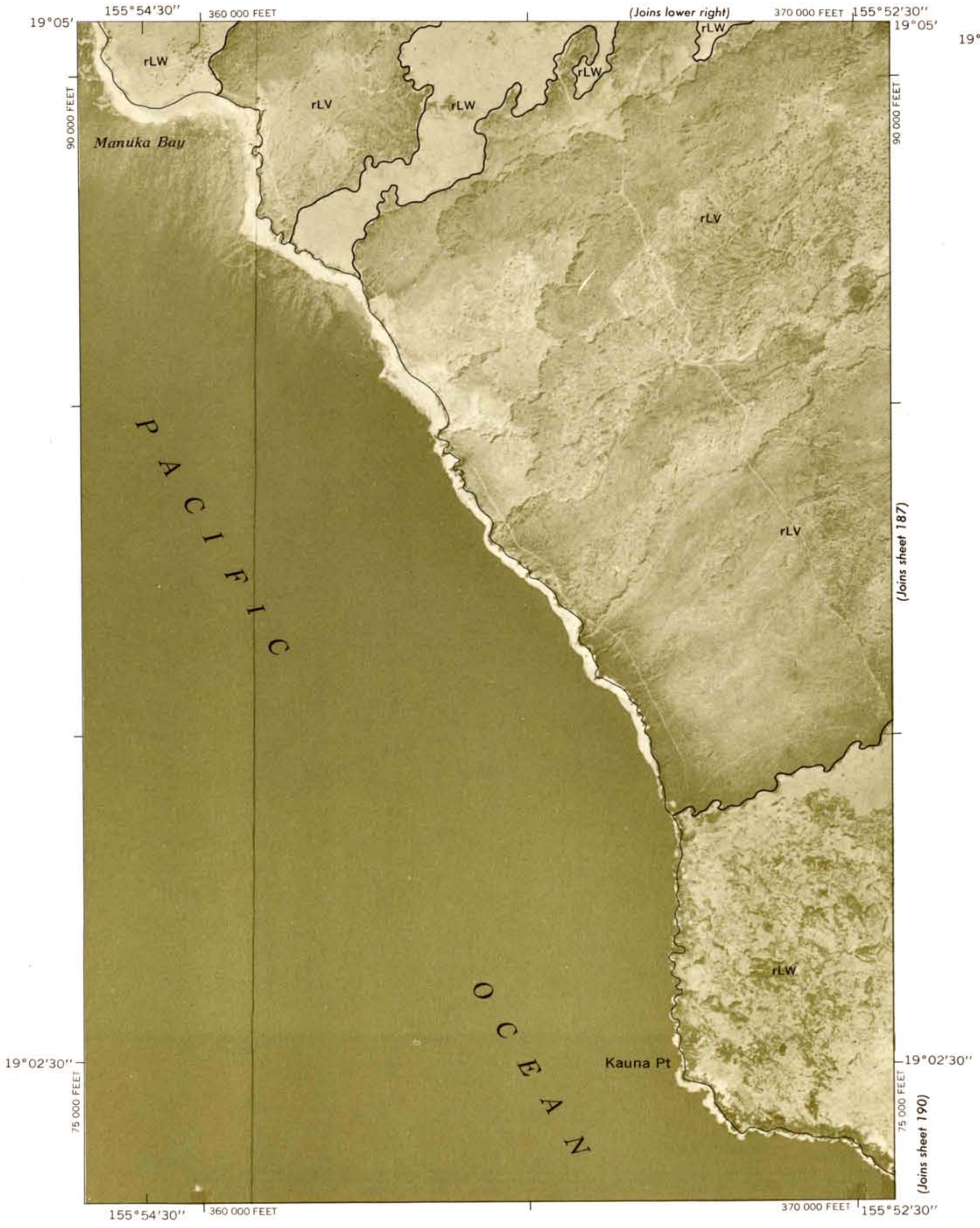
INSET A



HAWAII ISLAND, HAWAII NO. 183

Photobase from 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 1. Old Hawaiian datum.

INSET B

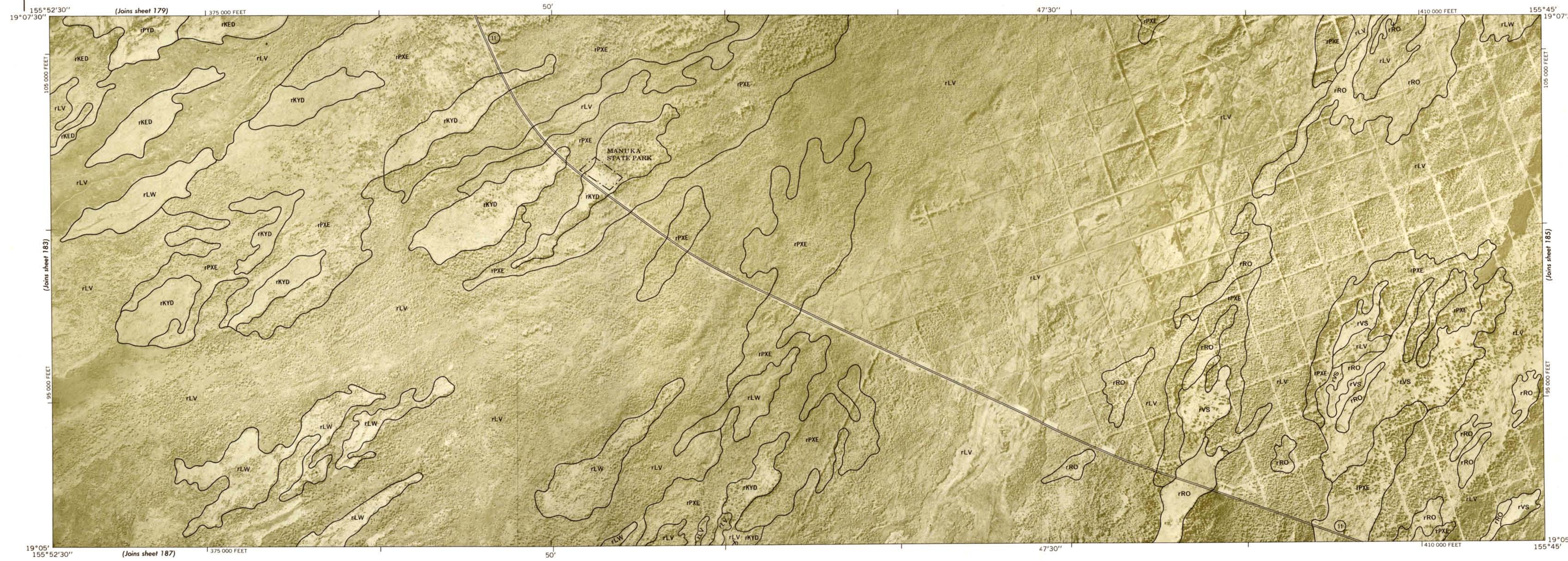


Scale 1:24 000

1 ¾ ½ ¼ 0 1 2 Miles

5000 4000 3000 2000 1000 0 5000 10000 Feet

HAWAII ISLAND, HAWAII — SHEET NUMBER 184



Scale 1:24 000

1 ¾ ½ ¼ 0 1 2 Miles

5000 4000 3000 2000 1000 0 5000 10000 Feet

Photobase from 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 1. Old Hawaiian datum.

This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the University of Hawaii Agricultural Experiment Station.

HAWAII ISLAND, HAWAII NO. 184

This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the University of Hawaii Agricultural Experiment Station.

HAWAII ISLAND, HAWAII NO. 185

Photobase from 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 1. Old Hawaiian datum.

Scale 1:24 000

1 ¾ ½ ¼ 0 1 2 Miles

5000 4000 3000 2000 1000 0 5000 10000 Feet

HAWAII ISLAND, HAWAII — SHEET NUMBER 186

Scale 1:24 000

1 ¾ ½ ¼ 0 1 2 Miles

5000 4000 3000 2000 1000 0 5000 10000 Feet

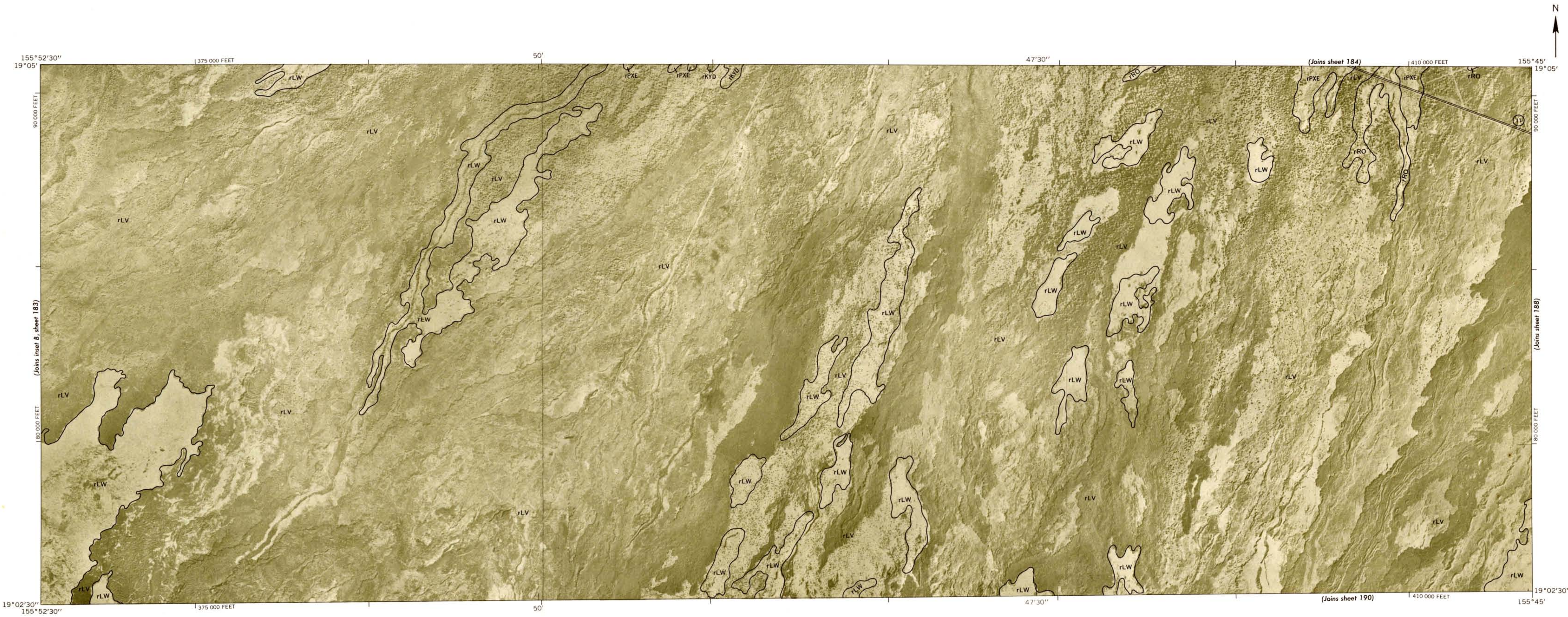
Photobase from 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 1. Old Hawaiian datum.

HAWAII ISLAND, HAWAII NO. 186

This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the University of Hawaii Agricultural Experiment Station.

This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the University of Hawaii Agricultural Experiment Station.

HAWAII ISLAND, HAWAII NO. 187



Photobase from 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 1. Old Hawaiian datum.

Scale 1:24 000

1 ¾ ½ ¼ 0 1 2 Miles

5000 4000 3000 2000 1000 0 5000 10000 Feet

N

155°45′ 415 000 FEET (Joins sheet 185) 42′30″ 40′ 455 000 FEET 155°37′30″

19°05′ 90 000 FEET (Joins sheet 187) 80 000 FEET 19°02′30″

19°05′ 90 000 FEET (Joins sheet 189) 80 000 FEET 19°02′30″

155°45′ 415 000 FEET (Joins sheet 191) 42′30″ 40′ 455 000 FEET 155°37′30″

Scale 1:24 000

1 ¾ ½ ¼ 0 1 2 Miles

5000 4000 3000 2000 1000 0 5000 10000 Feet

Photobase from 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 1. Old Hawaiian datum.

HAWAII ISLAND, HAWAII NO. 188

This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the University of Hawaii Agricultural Experiment Station.

This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the University of Hawaii Agricultural Experiment Station.

HAWAII ISLAND, HAWAII NO. 189

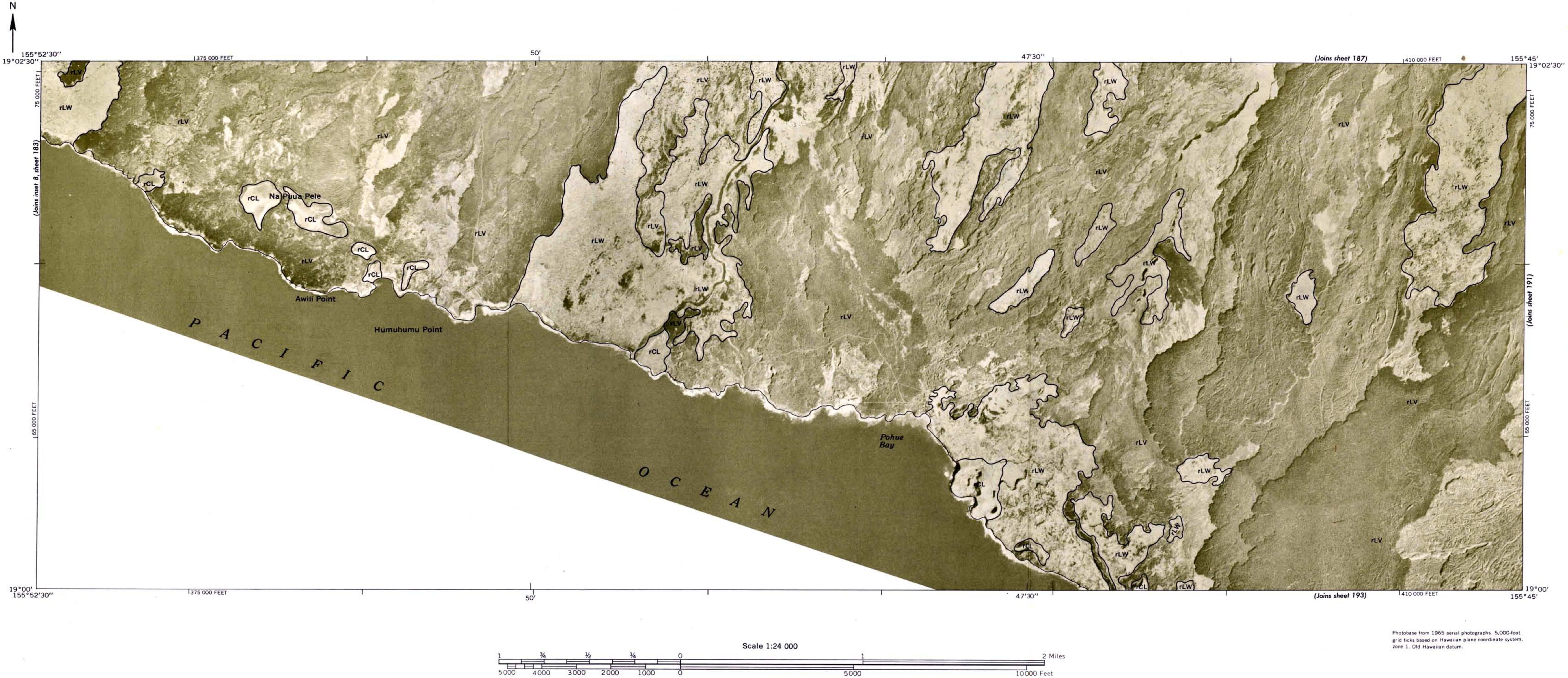
Photobase from 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 1. Old Hawaiian datum.

Scale 1:24 000

1 ¾ ½ ¼ 0 1 2 Miles

5000 4000 3000 2000 1000 0 5000 10000 Feet

HAWAII ISLAND, HAWAII — SHEET NUMBER 190



Photobase from 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 1. Old Hawaiian datum.

HAWAII ISLAND, HAWAII NO. 190

This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the University of Hawaii Agricultural Experiment Station.

N

This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the University of Hawaii Agricultural Experiment Station.

HAWAII ISLAND, HAWAII NO. 191

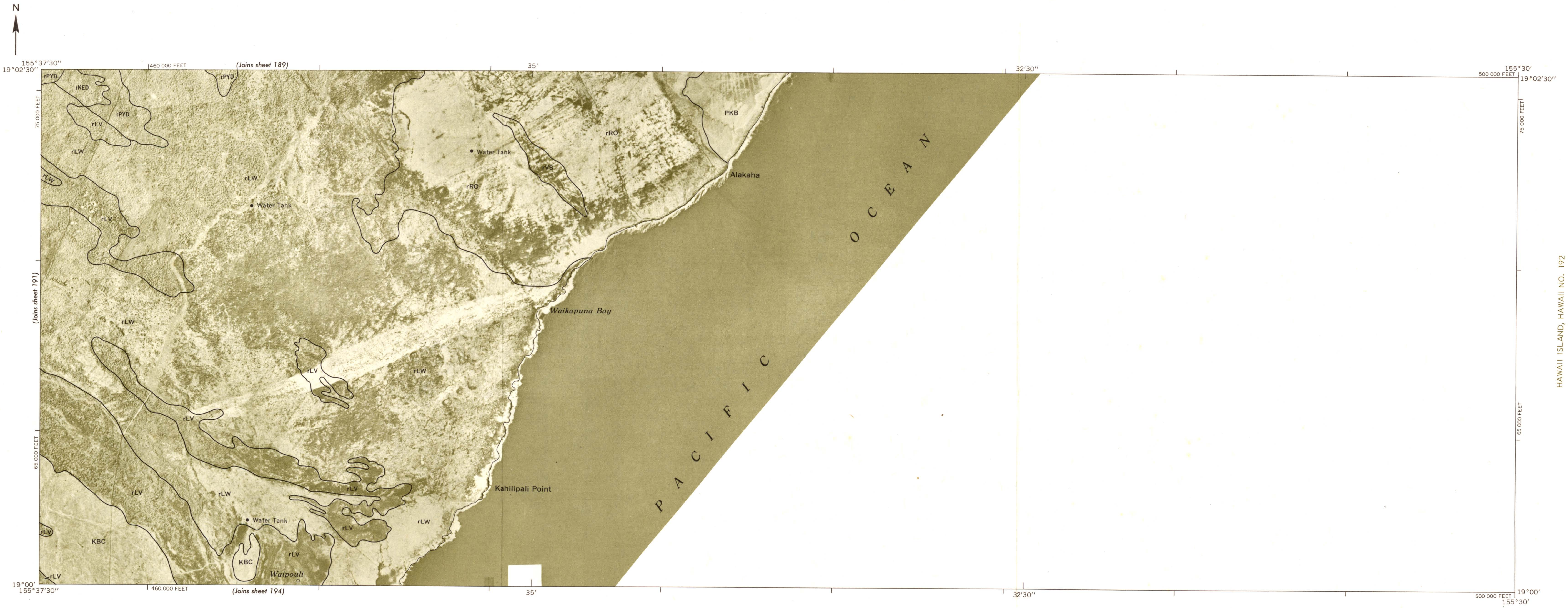
Photobase from 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 1. Old Hawaiian datum.

Scale 1:24 000

1 ¾ ½ ¼ 0 1 2 Miles

5000 4000 3000 2000 1000 0 5000 10000 Feet

HAWAII ISLAND, HAWAII — SHEET NUMBER 192



HAWAII ISLAND, HAWAII NO. 192

This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the University of Hawaii Agricultural Experiment Station.

Scale 1:24 000

1 ¾ ½ ¼ 0 1 2 Miles

5000 4000 3000 2000 1000 0 5000 10000 Feet

Photobase from 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 1. Old Hawaiian datum.

This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the University of Hawaii Agricultural Experiment Station.

HAWAII ISLAND, HAWAII NO. 193

Photobase from 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 1. Old Hawaiian datum.

Scale 1:24 000

1 ¾ ½ ¼ 0 1 2 Miles

5000 4000 3000 2000 1000 0 5000 10000 Feet

HAWAII ISLAND, HAWAII — SHEET NUMBER 194

N

Scale 1:24 000

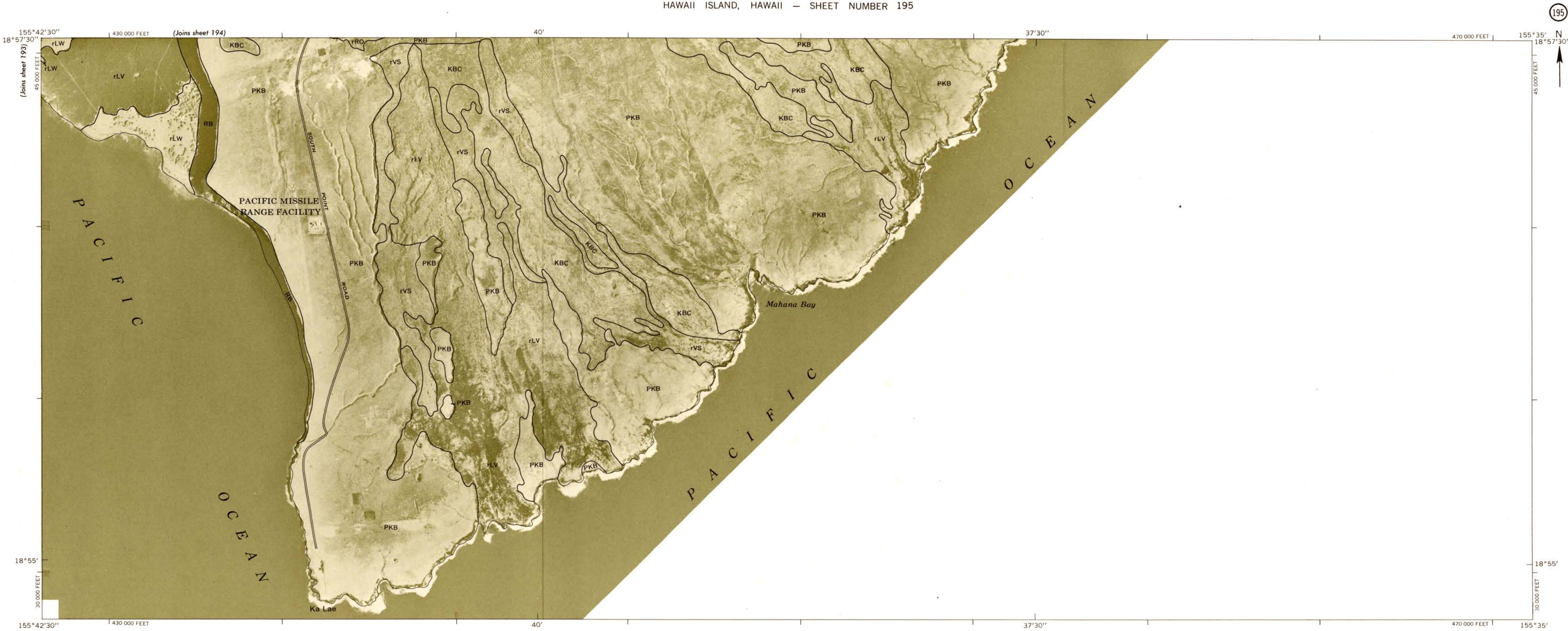
1 ¾ ½ ¼ 0 1 2 Miles

5000 4000 3000 2000 1000 0 5000 10000 Feet

Photobase from 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 1. Old Hawaiian datum.

HAWAII ISLAND, HAWAII NO. 194

This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the University of Hawaii Agricultural Experiment Station.



This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the University of Hawaii Agricultural Experiment Station.

HAWAII ISLAND, HAWAII NO. 195

Photobase from 1965 aerial photographs. 5,000-foot grid ticks based on Hawaiian plane coordinate system, zone 1. Old Hawaiian datum.

Scale 1:24 000

1 ¾ ½ ¼ 0 1 2 Miles

5000 4000 3000 2000 1000 0 5000 10000 Feet